Simulation of biological plants

working with municipal solid waste

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Abstract

To build mechanical biological plants, municipalities and engineer departments need tools to compare different proposals.

The methodology to test a plant aims knowing the flow sheet of each stream in the composting or anaerobic digestion plant, quantifying the weight of refuses, gas losses, stabilised waste and compost. With a universal model of matter we can establish the material balance for dry matter, organic matter, and various categories of MSW.

With a library of equipment tools and various kinds of waste, many simulations become possible in fictive plants. The validation of the simulation software has been successfully tested after the plant building. The first software was developed under excel but today, it has been improved through a special application of Ecoval, named Compowaste.

Keywords

MBT, MSW, Municipal Solid Waste, Simulation, Compost, Composting, Impurities.

1 Introduction

In France more than a hundred MBT plants were working twenty years ago. Most of them stopped because without maturation there was little difference with direct land spreading. Before 1998 all composts made with MSW had high levels of heavy metals and impurities.

French standards appear in 2006 for compost agriculture uses, to oblige composting plants to produce good composts, otherwise they had to close in February of 2009. If the quality of compost obtained from MSW and from biowaste is the same, a composting plant of MSW will be economically very interesting, considering the costs of landfilling or incineration.

Nowadays composting and anaerobic digestion plants are quickly growing in Europe. About eighty projects to treat two million tons of municipal solid waste are starting in France.

To compare different proposals the analyses must be made in the same way for each flow, for the inputs and the outputs and for every machine. In consequence the comparison is easier.

2 Methodology

The simulation is based on models. Some rules are used for sampling, analyses, material balance of tools.

2.1 Sampling

Sampling is based on European standard EN 14899 about Characterisation of waste, sampling of waste materials. For each flow in a plant, a sampling plan is prepared, depending on the type of analysis. Generally a probabilistic sampling is made, so each element has an equal chance to be selected.

2.2 The model of matter

The model of matter is standardised in France with dry matter sorting AFNOR XP X30 466 for MSW or Biowaste in March 2006. This model replaces the characterisation MODECOM on wet matter, which is not usable for outputs or intermediate flows in composting plants, because the wet matter of each category various for different flows (papers for example).

It is possible for MSW and Biowaste to estimate a dry matter composition with a wet matter composition, the opposite also but the result is biased.

2.2.1 Drying

Samples are dried at 70°C because at 100°C some plastics are destroyed or clogged. The wet matter contents are only biased about 0.5%. The water content is globally known for each flow.

2.2.2 Sieving

The sieving is done with a trommel. Round holes of 100, 20 and 8 mm are used on the dry matter for each flow.

2.2.3 Sorting

Fractions upper than 8 mm are sorted in 14 categories: putrescibles, papers, cardboards, complexes, textiles, sanitary textiles, plastics films, other plastics, miscellaneous combustibles, glasses, ferrous metals, other metals, miscellaneous incombustibles, special waste. All the fraction upper than 100 mm, 5 kg of 20 to 100 mm, 500 g of 8 to 20 mm are analysed. The fraction below than 8 mm can be analysed by ignition loss or impurities measurements.

2.3 Precision

Before doing the material balance, we must calculate or estimate the standard deviation of each result.

The calculation can be done with many measurements or by the Gy formulas used for sampling particulate matter. For compost made of a given composition, the fundamental variance (linked to the sampling) of mistake of the measure of a given parameter is the following one:

$$\mathrm{VAR(FE)} = \frac{Z}{Ms} \quad Z = \sum_i Z_i \text{ And } Z_i = (A_i - A_{moy})^2 T_i Mf_i$$

Formula in which:

- Ms is the mass of compost dried at 70 °C,
- A_i is the content of the parameter in a fragment of clue i,
- A_{moy} is the average content of the parameter in the compost,
- T_i is the weight content of fragments of clue i in the compost,
- Mf_i is the mass of a fragment of clue i.

2.4 Material balance

The Bilco software of the French firm Brgm is used to build a material balance. Due to errors, the measurements are inconsistent. The measurements are redundant and incoherent. The objective of the data reconciliation is to find a set of estimates of the measured values which are closed as possible to the measurements. It is possible also to calculate the estimate errors from the measurements errors. Due to the redundancies, the estimates are always more or as accurate as the measurements.

3 Simulation

3.1 The library of tools

The main tools used in plants are sieves, rotating drums, selective conveyors, densitometric tables, overbands, composting parks with some parameters as aeration and turnings, drying, watering, etc.

For each tool, the input and the outputs are measured in existing plants. In the end statistics are done to obtain a model.

3.2 The input

The MSW matter is described by dry matter and by the water content, in an excel file. This file has to be closed and placed in the same path of the project management.

Table 1 Example of MSW input in % DM

Categories	> 100 mm	20 to 100 mm	8 to 20 mm	Total
Food and garden waste	0.3	11.82	12.66	24.78
Papers	3.28	1.67	0.03	4.98
Cardboards	1.12	1.23	0.08	2.43
Complexes	0.23	1.18	0.07	1.48
Textiles	2.06	0.97	0.03	3.06
Sanitary textiles	8.79	11.76	0.07	20.62
Plastics films	3.81	1.2	0	5.01
Other plastics	1.04	1.31	0.27	2.62
Miscellaneous combustibles	0	1.96	1.45	3.41
Glasses	0	0.08	0.13	0.21
Iron metals	0	1.04	0	1.04
Other metals	0.42	0.3	0.01	0.73
Miscellaneous non combustibles	0.24	0	0.58	0.82
Special waste	0	0	0	0
< 8 mm				28.82

The total is equal to 100 and the wet matter about 42.5% DM.

Biowaste can be also used. It is interesting to measure the fraction below than 8 mm because these elements increase in a composting plant to make compost.

3.3 The graph drawing

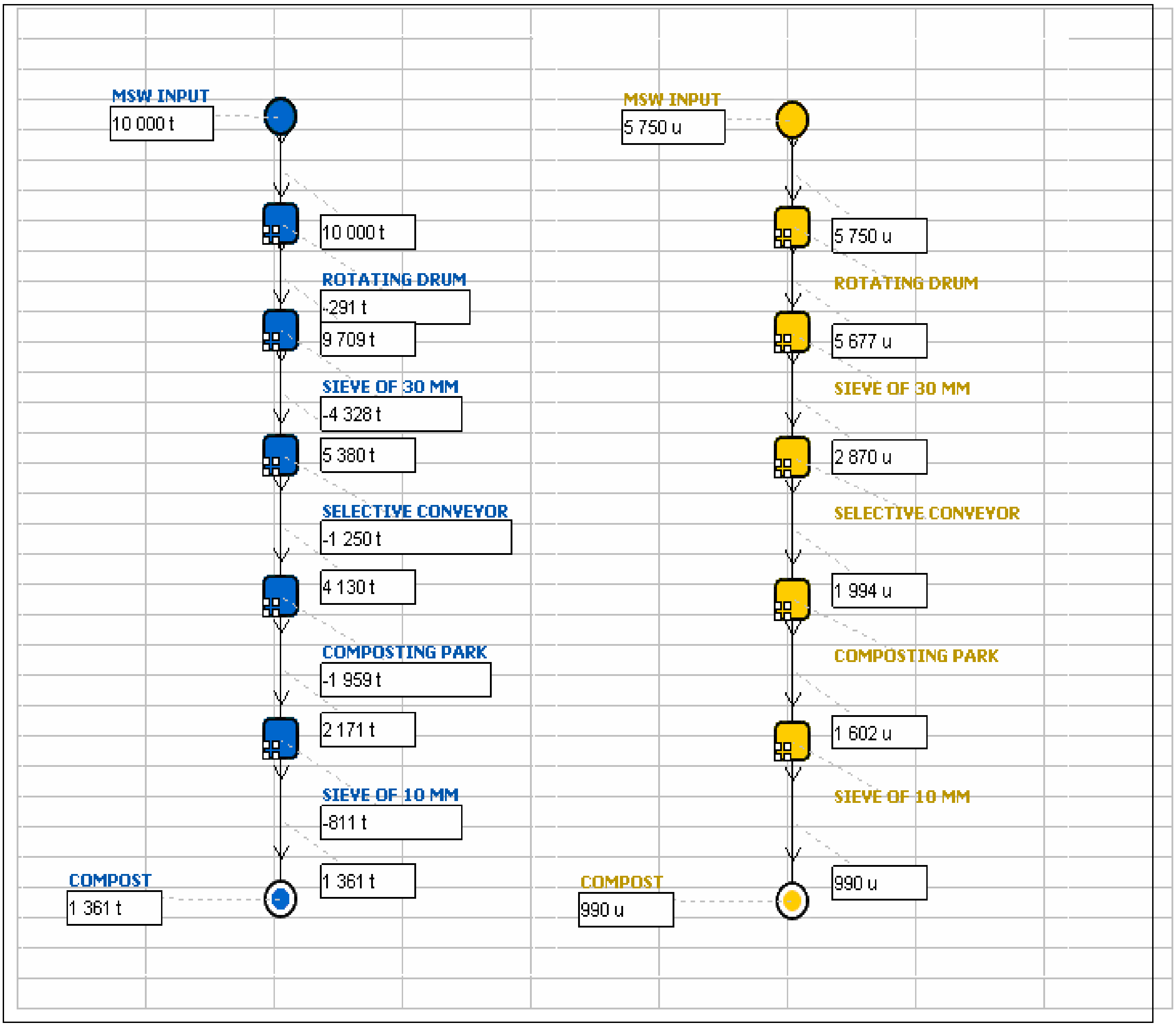

Figure 1 The graph drawing in wet and dry matter

Some parameters are defined for each equipment or tool. In a special window of Compowaste we can follow the state of the process and modify it.

3.4 Modifications

It is possible to modify the input composition, the parameters of each tool, the graph or the scheme plant. The result is immediately calculated and shown in a special window.

A new tool or model is created by changing the outputs compositions. Then, in a new project, you use one of these outputs as input to simulate as you want but always in the same basis of matter description. Anaerobic digestion, shredders and new sieves are tested but the simulator only uses performed models.

3.5 Calculations

Compowaste works with Ecoval, software developed by Diadème Ingénièrie since 2005. The simulator calculates the composition of each flow in mass or in percentage.

Table 2 Example of reject upper than 30 mm in % DM

Categories	> 100 mm	20 to 100 mm	8 to 20 mm	Total
Food and garden waste	0	2.95	0.96	3.91
Papers	13.37	10.06	0.63	24.06
Cardboard	0	0	0	0
Complexes	0.39	2.01	0	2.4
Textiles	7.41	1.67	0	9.08
Sanitary textiles	0.3	0.77	0.05	1.12
Plastics films	8.07	3.7	0	11.77
Other plastics	8.81	9.01	0.11	17.93
Miscellaneous combustibles	0.99	2.86	0.05	3.9
Glass	0	5.74	0.22	5.96
Iron metals	2	3.21	0.03	5.24
Other metals	1.43	0.76	0	2.19
Miscellaneous non combustibles	0	4.56	0.17	4.73
Special waste	0	1.17	0	1.17
< 8 mm				6.54

These results, for each flow, can be exported in another excel file.

4 Uses

4.1 Material balance in composting plants

All Mechanical Biological Treatments plants can be tested by simulation:

- MBT with composting and landfilling,
- MBT with composting, anaerobic digestion and landfilling,
- MBT with composting, compost uses, anaerobic digestion, RDF and landfilling.

The knowledge of outputs is important, but almost them the production of RDF with a high calorific value becomes a good way taking into account the price of energy. The table 2 shows RDF will be easily produced by taking off glass, iron and stones.

4.2 The economic point of view

The simulation will be done according to the prices of:

- Investment,
- Landfilling,
- Energy: biogas and electricity,
- Operating cost.

The equipment costs only represent 25% of the investment. An economy of 5% on the equipment is quickly lost by the operating cost because per example a trommel length of 8 meters instead of 10 meters, an input flow of 12 tons per hour instead of 10 tons per hour, small wide of conveyors. An economy on a rotating drum will immediately increase papers in landfills.

What is the most important now? Producing energy from biogas and put composts in landfills with taxes or producing composts without landfilling?

MBT with composts agriculture uses or landscape uses is cheaper but creates problems to publish the European Directive on biowaste.

4.3 The waste management

The main public aim is to improve the recovery rate and to decrease the rejects for land spreading or incineration.

It is clear that the quality of composts made from MSW can be the same as the quality of those made from biowaste, if the best available technology is used.

The best technology used for MSW composting consists on the following sequence: separate disposal of special waste, mainly batteries and WEEE (waste electrical and electronic equipment); rotary drum during four days; sieving at 30 mm; double selective conveyor; second sieving at 10 mm; maturation. It is possible to do better, but already the compost of Lantic in France is not far from the Ecolabel standard! Better composts should be made after sieving at smaller holes than 10 mm.

Instead of landfilling 200 kg per inhabitant with selective treatment of biowaste and MBT process, it is possible to landfill only 125 kg without selective collection of biowaste, MSW composting and MBT for all rejects.

4.4 Users

The engineer must use a simulator to know, with the best accuracy, the material balance of his project or of many projects. Now we find in composting or anaerobic plants precisions on flows about 10 to 20%, more in some cases! Nowadays that is unacceptable.

Researchers are interested in the simulation, to improve plants by new models, by new tools. The composting plant of Lantic working with MSW since 2004 was simulated in 2002. First we analysed the MSW according to dry matter method, then we chose a rotating drum for 4 days of stay duration seen in Canada and in the South of France, a sieve with holes of 30 mm at Paris, a double selective conveyor at Mont de Marsan and at least a flip flow sieve found in a quarry. Each tool was tested and analysed according to the dry method, not standardised in 2002.

Managers need simulations. A simulator like Compowaste for technical problems associated with an economic point of view should improve the waste management. Many ideas can be tested. Obviously the problems are not similar in European countries, but why is it forbidden to make agriculture compost with MSW in some countries?

5 Conclusion

What is new? The matter description is made on dry matter and the water content is globally known. Trommel are used to sieve at 100, 20, 8 and soon 5 and 2 mm. Composting MSW or biowaste is based on the characterisation of organic matter by chemical fractioning and estimation of its biological stability.

Compowaste is based on Cemagref models obtained since thirty years in composting plants.

In France we have now eighty projects, forty MBT with agriculture uses, thirty MBT with anaerobic digestion, ten MBT with stabilisation and landfilling. Soon France will treat 3 million tons of MSW by MBT.

6 Literature

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