

# ENERGY RECOVERY FROM MIXED FRACTION OF MSW THROUGH PRESSURE SEPARATION AND ANAEROBIC DIGESTION OF THE WET MATERIAL

F. DE POLI

*ENEA, Via Anguillarese 301, Italy*

**SUMMARY:** High-pressure separation, through extruder press machinery, was tested for the treatment of source separated MSW, followed by anaerobic digestion. The energy consumption is as low as 5% of the produced energy. The production of biogas is 200 m<sup>3</sup>/t of wet fraction, and the stability and quality of the output matter are interesting.

## 1. INTRODUCTION

The mixed fraction of MSW, the materials that remains after separate collection of the recyclable components of the urban waste, still contains large quantities of energy.

The recovery of this energy is usually managed in incinerators, but the caloric value is reduced by the organic fraction, that still contains large amounts of water (45 – 72 % TS).

The waste composition, after separate collection, is shown in Figure 1; they were measured in two different situations, in Italy and Germany.

It is important to notice that the organic fraction is similar in the two situations, and still represents a large percentage of the waste.

## 2. ANAEROBIC DIGESTION

### 2.1 Biogas from organic fraction

Anaerobic digestion is the only process that can recover energy from wet material.

If the moisture content is over 30%, as it usually occurs in the case of food residues, the energetic balance of combustion is negative.

The burning of these materials in incinerators is still possible, as the combustion is supported by paper and plastic; but if their concentration is reduced by separate collection, the only way to recover energy is the separation of the wet components and the production of biogas.

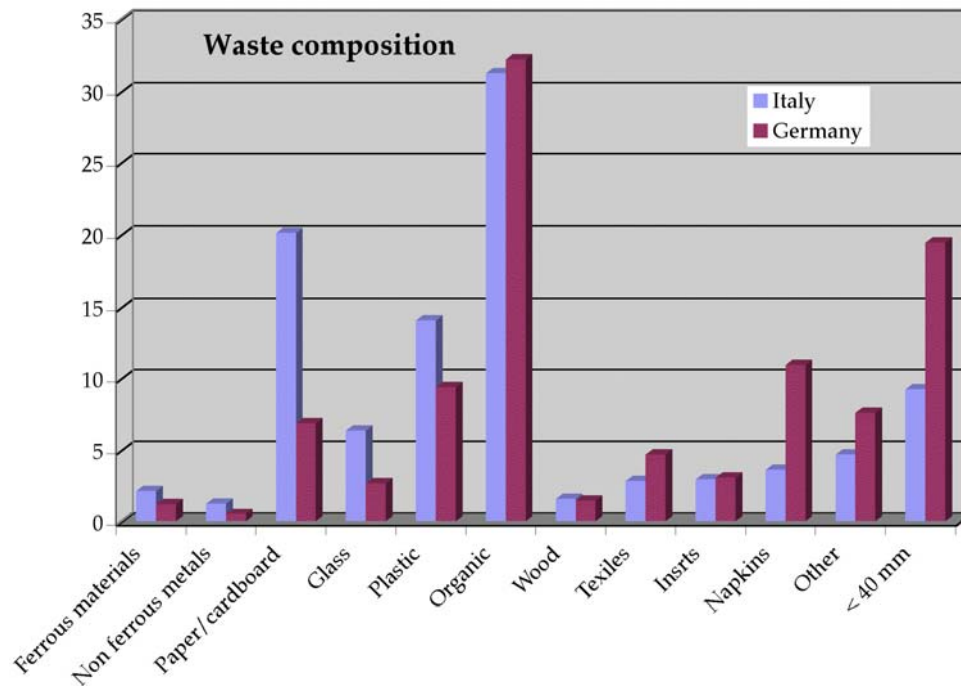


Figure 1. Composition of the waste obtained after municipal separate collection in two different countries. In both cases the rate of separate collection was almost 50%.

The aerobic processes, with the production of compost, can be useful for the stabilisation of the waste, in order to make it suitable for land recovery or similar purposes, but requires energy and very often do not allow the material to be used in agriculture.

Several trials were done to produce biogas from waste; from the historical point of view, the first real scale digester was built in Bellaria, on the Adriatic coast of Italy in the year 1984, but it required the dilution of the waste, which implies that the volume of digestate is greater than the volume of the input waste.

Several design of dry fermentators were tried in the last few years, but the high content of indigestible components gave poor results in most cases.

Biogas is an interesting energy vector, as it can be used directly in reciprocate engines or boilers, and it is naturally produced by organic matter when the operating conditions for anaerobic digestions are met.

## 2.2 Separation process

Among the several possibilities of separating the organic matter from the mixed waste, the technology of pressure-separation was chosen.

With this technology, the separation is done through a specially designed extruder press, that separates the input waste into two fractions: a dry one, to be sent to thermal conversion, and a semi-solid one, that seems to be interesting for anaerobic digestion.

The municipal waste, fed into the extruder press, undergoes a very high pressure in a perforated extrusion chamber: this results in a fluidization of the actual organic parts (food residues, various putrescible fractions) which are pushed out by the difference in pressure between the interior and exterior of the chamber and are, consequently, separated from the mechanically more resistant parts (paper and carton, plastics, rubber etc.).

The press can be directly fed with the waste; it only requires the cutting of the sac; the use of this kind of press do not requires the grinding of the material before the treatment.

This strongly reduces the contamination of the substrate by heavy metals and other dangerous components.

The result is that the output material after anaerobic digestion shows a high quality of the digested matter that can be analysed in view of a possible agronomic utilisation.

The energy consumption of the press is low, if compared with other separation systems, both dry and wet.

The typical consumption is 12 kWh/t of input waste, which means almost 5% of the energy that can be obtained by the conversion into electricity of the biogas produced by the process.

### 2.2.1 Organic matter gel (GMO)

The wet material has a consistency similar to a dense gel that does not release free water.

This is relevant for three reasons: first one is that it can be stored in tanks without leaking of liquids.

The second one is that it can be easily pumped and mixed with the digestate, for a simpler control of the process.

The third one is that there is no separation of the phases when fed into a plug-flow digester; this is very important, as no separation occurs inside the digester, where the material is treated for a long period, up to 50 days.



Figure 2. The press in operation

This GMO shows a water content of 38 – 56%, depending on the composition of the input waste.

The VS content is ranging from 51 to 60% of the TS.

In laboratory tests the conversion into biogas was from 48 to 53%.

In a time period of 22 days, over 50% of the VS are converted into biogas, showing a high stabilization of the digested matter.

### 3. EXPERIMENTAL STUDY

#### 3.1 Description of the plant

##### 3.1.1 The press

The extruder - press have a treatment capacity of 30 – 35 t/h, and operates at the pressure of 280 bar.

The main characteristics of the machinery are reported in Table 1.

The input waste is pushed in the extrusion chamber to the working pressure; under these conditions the organic fraction is somehow liquefied, and passes through the holes.

A special alloy drum, constituted of three cylinders, is placed in the centre of the chamber, and it is made to rotate by an oleo-dynamic device.

The treatment cycle is constituted by three phases: the feeding, the true compression, and the extraction; the last phase is driven by a secondary cylinder, that pushes out the dry fraction.

The percent of dry fraction is dependent on the composition of the input waste, and usually is from 55 to 60% of the input waste.

The wet fraction (GMO) coming out the process is from 10 to 13 t/hour, which means almost 100 t/day with a working time of 8 hours.

The device can work over 20 hours/day, and the production of GMO can rise to 250 t/day.

##### 3.1.2 The anaerobic digester

The anaerobic digester used for this experience is placed in Kaiserslautern, Germany, and operates from December 1998.

It is a vertical plug-flow reactor, designed to operate dry anaerobic digestion; the total volume is 2450 m<sup>3</sup>.

Before the installation of the extruder – press, the system used for the pre-treatment of the waste was a classical cascade mill, followed by a screening (40 mm) and a magnetic over belt separator.

The use of the extruder – press allows a better quality of the material constituting the input of the digester, and it produces a lower amount of the waste after anaerobic digestion.

Table 1. Characteristics of the extruder – press.

Length	20.000 mm
Width	14.000 mm
Height	5.000 mm
Installed power	650 kW
Typical power consumption	400 kW
Working power	280 bar
Weight	300 tons
Specific consumption per t of input waste	11,5 – 13 kWh

A fraction of the output material is mixed with the fresh GMO before it is fed into the digester; the mixing rate is one of the principal control parameters for the anaerobic digestion.

When operating on real scale, the control of the process must be done with external procedures, as it is impossible to empty the digester, or to change the substrate.

The digester must be seen as a “black box” transforming organic matter into biogas; the process temperature can be hardly changed, and the addition of chemicals is costly and dangerous.

There are two ways only, for controlling the process: the feeding rate and the mixing rate.

The hydraulic retention time can vary from 20 to 35 days, but through the mixing you can increase the retention of the active bacteria up to three times.

#### 4. RESULTS AND DISCUSSION

After the installation of the extruder – press, the digester was fed with GMO starting from January 2006.

The GMO was loaded

As said on point 2.2.1, with a HRT of 22 days, over 50% of the VS are destroyed and converted into biogas.

This results in a high stabilization of the digested matter; the results in terms oxygen demand are still under exam; they seem to be very interesting, but they will be presented in future, when a longer experience will occur.

It is particularly interesting to notice that a very high percent of the digestible organics were converted into biogas, and very low biogas emissions are reported if the material is sent to landfill sites, and subjected to the anaerobic environment of the landfill.

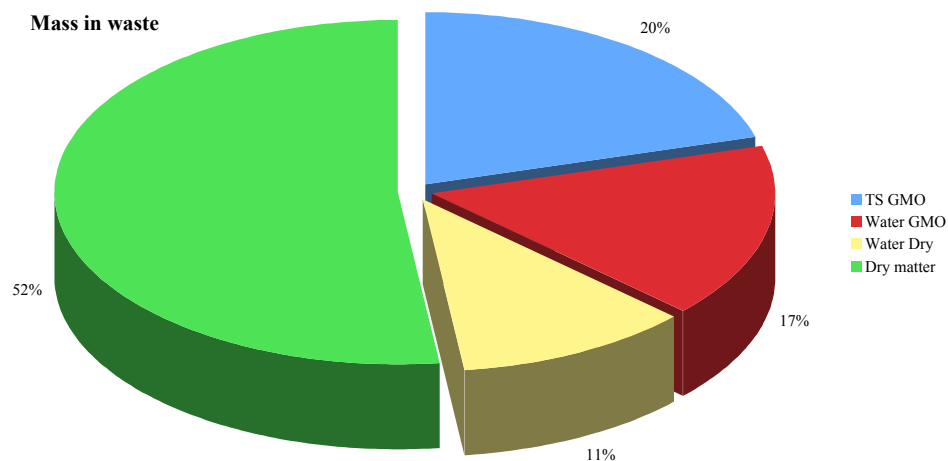


Figure 3. Dry matter and water in the input waste.

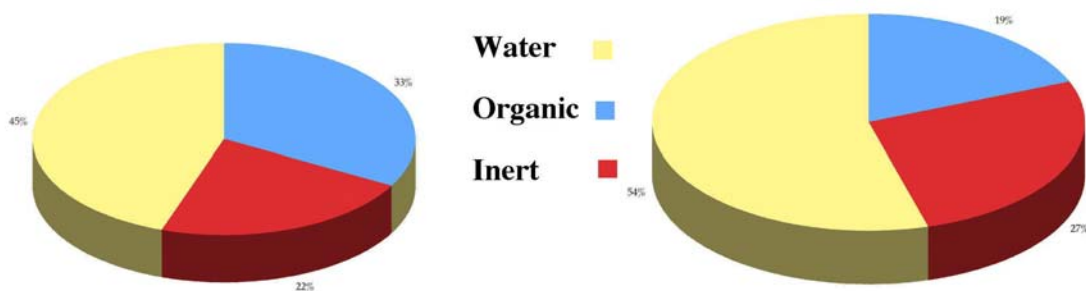


Figure 4. Components before and after anaerobic digestion.

It is interesting to notice the change in the percentages of the different components due to anaerobic conversion of the organic matter.

The specific production of biogas was measured on a large number of days, in order to statistically estimate the average yield.

The biogas production resulted in 0,71 m<sup>3</sup> of biogas per kg of VS added, with an energy efficiency of almost 67%.

The apparent high efficiency of the process can be explained by the increase of the percent of not digestible VS in the output; even the small plastic particles and other not fermentescible materials pass through the press, and they result as part of the VS, due to the analytical system in use.

The average global production was 200 m<sup>3</sup> of biogas per t/GMO added.

## 5. CONCLUSIONS

High-pressure separation, through extruder – press machinery, seems to be an interesting pathway for the preparation of material to be sent to anaerobic digestion.

The energy consumption resulted 12 kWh/t of treated waste, much lower than the one required by other solutions, such as water treatment or milling and screening; it represents almost 5% of the produced energy.

Further investigations are required to define the possibilities of utilisation of the digested matter that shows high stability and quality, even if its use in agriculture is not yet allowed by the legislation of some European Member States.

## ACKNOWLEDGEMENTS

The Author wishes to thank Carlo Gonella, Enrico Vincenti and the ZAK of Kaiserslautern for their collaboration and support.

## **REFERENCES**

- Bonzonella D., Pavan P., Mace S., Cecchi F., (2005) Dry anaerobic digestion of differently sorted organic municipal solid waste: a full scale experience. In: Fourth International Symposium of Anaerobic digestion of Solid Waste, Copenhagen, Denmark, vol. 1, pp. 85–92.
- Chynoweth D.P., Owens J.M. and Legrand R. (2001) Renewable methane from anaerobic digestion of biomass, *Renew. Energ.* 22 (1–2) (2001), pp. 1–8. Abstract | PDF (100 K)
- De Baere L., (2005) Will anaerobic digestion of solid waste survive in the future? In: Fourth International Symposium of Anaerobic digestion of Solid Waste, Copenhagen, Denmark, vol. 1, pp. 34–51.
- Gallert C., Henning A. and Winter J. (2003) Scale-up of anaerobic of the biowaste fraction from domestic wastes, *Water Res.* 37 (2003), pp. 433–441.
- Hartmann H., Ahring B.K. (2005) Strategies for the anaerobic digestion of the organic fraction of municipal solid waste—an overview. In: Fourth International Symposium of Anaerobic digestion of Solid Waste, Copenhagen, Denmark, vol. 1, pp. 34–51.
- Mashad H.M., Zeeman G., Loon W.K.P., Bot G.P.A. and Lettinga G. (2004) Effect of temperature and temperature fluctuation on thermophilic anaerobic digestion of cattle manure, *Biores. Technol.* 45 (2) (2004), pp. 191–201.