BIODEGRADABLE WASTE TREATMENTS – TECHNICAL ASPECTS

Carmencita CONSTANTIN[1], Ramona JELESCU[2], Radu FILIP[3*]

In Romania the main method for municipal biodegradable waste final elimination is landfilling. This solution which means to storage waste in big pits, even ecological ones (which comply with Landfill Directive 1999/31/EC) is not a long term option because does not really solve the problem, it only postpone it in the future increasing the costs.

To comply with stipulations of European Directive 1999/31/EC until 2017 suppose that Romania will find viable economical and technical solutions for reducing of the amount of biodegradable waste to 35% using as a reference the amount of waste produced in 1995.

Implementing well known methods of biodegradable waste treatment like anaerobic digestion, composting, incineration) requires an important financial effort and that is why choosing the best technology (Best Available Techniques-recommended by Reference Documents elaborated by European Environmental Agency) involves both careful analysis of the specific area and location elements and the economical and technical conditions required for its application.

The final result of using such a technology or combination of technologies (anaerobic digestion, composting, incineration) would be the development of a viable waste management system.

The benefits of such a system are not only solving the waste final disposal problem but also a number of by-products, depending on the technology used, with an important economical value like electrical energy, heat, biogas and compost.

This article purpose is to make a comparison between anaerobic digestion and composting method from de designer point of view.

Keywords: landfilling, anaerobic digestion, composting method.

1. Introduction

Current situation of solid waste management in Romania shows absence of environment infrastructure, collecting and transportation equipments even if the amount of waste is constantly growing.

[1] Director of Energy & Environment Division, Institute for Studies and Power Engineering, Bucharest, Romania

[2] Environmental Expert Engineer, Institute for Studies and Power Engineering, Bucharest, Romania

[3] Environmental Engineer, Institute for Studies and Power Engineering, Bucharest, Romania (*Corresponding author)

Even if there are a lot of technical solution developed today in the field of waste management because of the lack of money and lower exploitation costs, Romania choose the landfilling method as solid waste managing solution.

The authorities must also cheep in mind the fact that Romania has negotiated terms to comply with the European Directive 1999/31/EC until 2017 which means that we have to find viable economical and technical solutions for reducing of the amount of biodegradable waste to 35% using as a reference the amount of waste produced in 1995.

That is why the solution for municipal solid waste management should consist not only in buying new trucks for waste collection and transportation, new bins or constructing new transfer stations and ecological landfields but also in applying technologies which will lead to a minimized amount of biodegradable municipal waste turned into a valuable product.

There are two important ways to treat biodegradable waste: through aerobic method which means composting and through anaerobic method which means anaerobic digestion or fermentation.

2. Anaerobic digestion

Anaerobic Digestion is a process, naturally occurring in the waste material, whereby organic waste is broken down in a controlled, oxygen free environment by bacteria. Methane rich biogas is produced thus facilitating renewable energy generation. As a result, materials that are currently going to landfill can be utilized; natural methane emissions are reduced and conventional generation with its associated carbon emissions is displaced. The residual nutrient rich liquor and digestate is suitable for use as fertilizer on the farmland surrounding such a plant, reducing the need for artificial fertilizer.

The design of an anaerobic digestion installation has to consider in the first place the analysis of the waste composition. There are also other important factors which determine the reaction to take place and the biogas to be produced:

- Raw material;
- Temperature;
- Pressure;
- pH;
- Mixing.

The raw material has to ensure a favourable environment so the methane-producing bacteria could develop. This environment must have:

- 90% humidity;
- pH between 6.8 – 7.3;
- The ratio between Carbon content and Nitrogen content must be between 15 and 25;

- The raw material should not contain heavy metal, detergents, antibiotics, high concentration of sulphates, formalin, carbolic and polycarbolic.

However, the raw material can be any organic material as long as the C/N ratio is between 15 and 25.

Depending on the temperature, the methane - producing bacteria can be:

- Cryophilic bacteria for temperature between 12 – 24°C;
- Mesophilic bacteria for temperature between 25 – 41°C;
- Thermophilic bacteria for temperature between 45 – 60°C.

As a general principle, the higher the temperature, the faster the breakdown, the greater the production of gas and decreases the retention time of the raw material in the digester.

Pressure has also a great influence on the reaction meaning that at 0.4 bar the biogas production becomes insignificant. As a conclusion biogas production can happen only 4 meters under the surface layer of raw material.

During the reaction raw material segregation takes place and a peel is formed on the surface and that is why mixing is needed.

The acidity of the digestate can be adjusted by adding daily organic called daily feeding ratio with raw material.

After considering all this criterions we can calculate:

- Daily feeding ratio with raw material;
- Initial concentration of dry substance on raw material;
- Initial concentration of organic matter on raw material.

Area needed for erecting an industrial installation:

- Area for reception and unloading the waste;
- Area used for depositing the rejected waste;
- Area used for the installation.

Anaerobic digestion operation includes:

- Shredding the organic waste
- Separating metals;
- Primary mixing and pasteurization at 70°C;
- Heat extraction in a heat exchanger;
- Anaerobic fermentation;
- Gas extraction;
- Screen separating of plastic and non-decomposed material;
- Testing, monitoring and quality control of fertilizer.

Main equipment of anaerobic digester installation:

- Receiving silo;
- Coarse shredder;
- Magnetic separator;
- Mixing tank;
- Heat exchanger;

- Digester;
- Screen;
- Sludge press;
- Storage tank.

3. Anaerobic digestion advantages and disadvantages

The advantages are:

- Methane production: Providing potential energy source with possible revenue both from sale of the energy, and benefit from government tax, and (Kyoto agreement) CDM etc. payments arising from renewable fuels/non-fossil fuel incentives;
- Methane production: Anaerobic digestion contributes to reducing greenhouse gases by reducing demand for fossil fuels;
- Smaller reactor volume required;
- Biomass acclimatisation allows most organic compounds to be transformed ;
- Rapid response to substrate addition after long periods without feeding;
- End product can be potentially saleable products biogas, soil conditioner and a liquid fertiliser;
- Process more effectively provides sanitisation/removal of diseases.

The disadvantages are:

- Longer start-up time to develop necessary biomass inventory;
- May require alkalinity and/or specific ion addition;
- May require further treatment with an aerobic treatment process to meet discharge requirements;
- Biological nitrogen and phosphorus removal is not possible;
- Much more sensitive to the adverse effect of lower temperatures on reaction rates;
- May need heating (often by utilisation of process gas) to achieve adequate reaction rates;
- May be less stable after ‘toxic shock’ (e.g. after upsets due to toxic substances in the feed).
- Increased potential for production of odours and corrosive gases.

4. Aerobic digestion (composting process)

Aerobic digestion is a process that breaks down organic material (food wastes, biomass) by microorganisms under favorable conditions of oxygenation.

Managing the composting (turned windrows) process involves the balancing of a number of different variables, all of which have an interaction on the others:

- Feedstock composition and ratio;
- Particle size and porosity;
- Windrow construction;
- Oxygen;
- Moisture content;
- Temperature – residence time
- Carbon/nitrogen ratio;
- Turning frequency.

The organic waste and the structure fraction of materials, provide the nutrients for microbial activity and the beneficial properties that good compost needs like carbon, potassium, phosphorus and nitrogen. Bulking agents, such as wood chip provides added texture and structure to the compost.

The smaller particle size the greater the surface area for microbial activity. However, if the particle is too small the material will have a porosity that is insufficient to allow aeration. Appropriate shredding to the desired particle size and mixing with bulking agents is carried out to provide beneficial conditions for the composting process.

For turned windrow composting, the material to be composted is arranged in long rows (windrows) that are aerated by convective air movement, diffusion, and periodic mechanical turning that exposes the material to oxygen. The windrow should be constructed to optimize the composting process, which in itself is a balance between various parameters.

Must be considered the capacity of the turning equipment, the dimensions of the windrow because if its height is too small can cause loss of temperature and reduction of microbial activity.

The importance of oxygen is its availability for aerobic microorganism. The oxygen content in the compost during composting shall be approximately between 10 % and 18%. To meet that condition the free airspace in the compost during composting shall be approximately between 30% and 35%.

Another factor is the water essential for the chemical and biological reactions within the compost process. The optimum moisture content is between 50% and 60% and must not exceed 65%.

If the moisture content is too high cooling may occur, reducing microbial activity, the permeability to the air flow will be reduced and anaerobic condition may set in. If the material is to dry water can be added.

Temperature is an indicator of microbial activity because microorganism generate heat as a result of they breaks down organic material. Temperature measurements can indicate a number of aspects of the process:

- The rate of microbiological activity;
- The degree of microbiological activity (related to stability/maturity);
- The predominant type of microorganism (mesophilic or thermophilic);
- The degree of insulation of the windrow.

Temperature is one of the mechanisms involved in sanitization of material and plant, animal and pathogen kill. If temperatures are too high, water evaporates, microorganisms die or become dormant and when combined with a very high C/N ratio there is the possibility of spontaneous combustion. If the temperature is too low, microbial activity drops and slows the composting process. Turning the material releases heat and adds more oxygen.

Microorganism requires carbon and nitrogen. The nitrogen is used for protein manufacture and reproduction. The carbon is used for energy and growth. The ratio of these two elements is important in managing the composting process.

The C/N ratio must be between 20:1 and 40:1 but a C/N ratio between 25:1 and 30: 1 provides the best results.

Below 20:1 nitrogen is lost as ammonia or nitrous oxides which are odorous. To counteract this, more material with high carbon content can be mixed into the material. In order to control the odour, a biofilter (e.g. matured compost) or acid scrubber can be used.

The form that the carbon is in the raw material can make it slower to decompose (e.g. wood chips). This can be screened out and mixed with another batch that is being prepared for composting.

Turning frequency has to ensure that all the material is exposed to the composting process, to aerate the windrow so that there is sufficient oxygen available to the microorganisms and to evenly distribute moisture throughout the window.

Insufficient turning may result in overheating of the material or lead to anaerobic conditions and hence lower of the temperature. Too much turning can result in unnecessary cooling of the process, reduction in particle size and unnecessary generation of dust and bioaerosols.

Composting operations are:

- Shredding the structural material with high carbon content so it can be mixed with organic municipal waste fraction;
- Turning the windrow to ensure full compositing of the organic parts;
- Screening drum for ensuring homogeneous compost;
- Separating the plastic and metal from compost;
- Irrigation of compost with water in the summer time;
- Testing, monitoring and quality control of final product;
- Blending and stockpiling of final product.

Equipment needed:

- Shredder machine;

- Wheel loaders;
- Windrow turning machine;
- Screening drum;
- Air separator;
- Irrigation installation;
- Pumps and others.

Area needed for the compost facility:

- Area for raw material unloading and storage;
- Area for raw waste shredding;
- Area for composting process;
- Area for compost maturing;
- Area for storage until the compost is transported to the final destination;
- Additional working area.

5. Aerobic digestion advantages and disadvantages

The advantages are:

- Waste is stabilized into a form which limits potential for leachate pollution;
- Pathogens are killed, rendering the material suitable for land spreading;
- Compost is a source of nutrients which improves soil physical condition increasing resistance to erosion and soil fertility and also captures carbon in the soil;
- Significant waste volume reduction;
- Reduces the use of chemical fertilizers and the environment impact produced by them.

The disadvantages are:

- Unreliable or uncertain material quality, risks rise mainly from the input of pollutants (heavy metals), overload of nutrients and accumulation of organic N-fractions;
- Odour problem can occur in the process;
- Market perception is low;
- May need large area of land.

6. Conclusions

- Both methods make an important contribution to a rational exploitation of waste, greatly reducing the "disposal requirements" in dumps or incinerators;

- They prevents the production of substances responsible for atmospheric pollution which are otherwise produced if this matter is burned;

- Quality source sorting and separate collection of biodegradable waste is an essential condition for applying successfully any of this solutions;

- Compost facility it will be more suitable for our country because the investment and exploitation costs are much lower then for the anaerobic digestion installation;

- In the near future achieving the goal of reducing the biodegradable waste landfilled by 50% and 75% of 1995 quantity, will require both methods.

REFERENCES

[1]. *V. Nikolic*, Producerea si utilizarea biogazului, Chiminform Data, Bucuresti, 2005.
[2]. *S. Serti*, "Operational manual for composting facility", SWECO, 2006.