THEORETICAL AND EXPERIMENTAL RESEARCH CONCERNING THE DEVELOPMENT OF A BIOGAS PLANT USING MUNICIPAL BIODEGRADABLE RESIDUES IN THE TIMISOARA AREA

CERCETĂRI PRIVIND DEZVOLTAREA UNEI INSTALAŢII DE BIOGAZ ÎN ZONA TIMISOARA

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Abstract: **This paper presents the potential use of municipal degradable residues in a biogas pilot plant that is under construction near the Timisoara area. The main topic is connected with the short presentation of the project that involved the pilot plant's construction, the main parameters of the pilot plant and the main effects of using this kind of technology in order to use all the energetic potential of the municipal residues. A lab pilot plant working using the anaerobic fermentation process - from the Laboratory of renewable energy resources of the POLITEHNICA University of Timișoara - was used for research to test the different types of biomass residues and to determine the main parameters of the process and the produced biogas. The achieved results are important for improving the anaerobic fermentation process in order to obtain large quantities of biogas with improved percentage of methane / CO_2 ratio.**

Key words: **Biogas, Municipal residues, Pilot plant**

Descriptori: Biogaz, Reziduuri municipale, Instalaţie pilot

Contribuţii

Contribuţia autorilor se referă la experimentarea soluţiilor de obţinere a biogazului din deşeuri de biomasă de natură vegetală pe staţia pilot şi interpretarea rezultatelor, respectiv elaborarea unui model îmbunătăţit de instalaţie pilot utilizat la producerea de biogaz din deşeuri municipale prin fermentaţie anaerobă în cadrul proiectului EPOC (Energie Pentru un Oraş Curat). Realizarea instalaţiei pilot s-a făcut împreună cu Universitatea POLITEHNICA din Timişoara, iar locaţia în care s-a realizat instalaţia aparţine S.C. COLTERM S.A.

1. Prologue

In the European Union, the continuous development generates large amounts of waste, leading to unnecessary losses of materials and energy, negative repercussions on the environment and adverse effects over health and quality of life. Reducing these negative effects is an EU strategic objective. Waste management is already governed by a substantial number of laws, but there are still opportunities to improve the management of certain important waste streams.[1] The processing of refuse was usually undertaken to reduce the pollution potential and volume for ease of handling and disposal. This perspective has since been adjusted to include the transformation of the waste, which was hitherto unwanted, into useful end-products.[2]

According to statistics, every EU citizen produces an amount of about 520 kg of municipal wastes. This amount is 13% more as compared to 1995. By 2020 is predicted a further increase to 680 kg per person, meaning an increase of almost 50% in 25 years. The largest European waste streams originate from construction or demolition and also in manufacturing activities. Most of EU municipal wastes are still sent to landfills (45%). However, more and more municipal wastes are recycled or composted (37%) or incinerated with energy recovery (18%).

Efficient disposal of municipal marketwaste (both vegetables and non vegetables) is always a sensitive issue to civic authorities since the presently available disposal processes like sanitary landfill, incineration, pyrolysis, etc., are always associated with pollution hazards posing a serious threat to public health. [3] Municipal solid waste (MSW), when landfilled, causes several environmental problems such as the biogas production, volatile organic compounds (VOC) emission, leachate, the presence of vectors (e.g., insects, rodents, and birds), public health hazard, risk of explosions, and plants toxicity, because of the presence of the biodegradable organic fraction.[4]

Because of this, there is important to develop a green technology for disposal of those wastes which is to be both cost effective and polution free. Connected with this, anaerobic digestion of energy crops, residues, and wastes is of increasing interest in order to reduce the greenhouse gas emissions and to facilitate a sustainable development of energy supply. [5]

Methane, which is the main component of biogas, is a valuable renewable energy source, but also a harmful greenhouse gas if emitted into the atmosphere. Methane, upgraded from biogas, can be used for heat and electricity production or as biofuel for vehicles to reduce environmental emissions and the use of fossil fuels. [6]

Related with the biogas production from biomass residues in european countries, Figure 1 will present the values for the most important representatives.

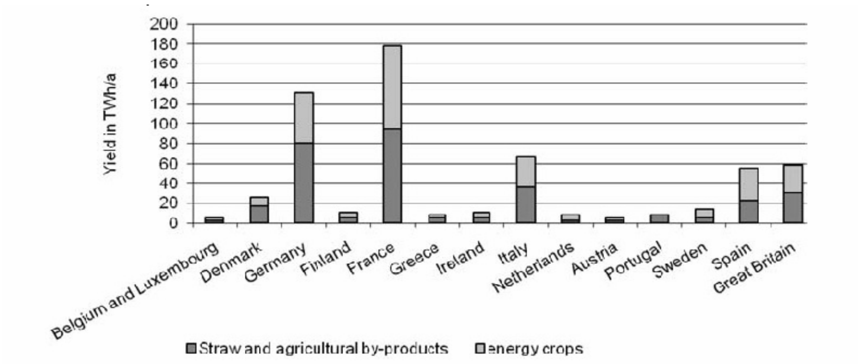

Figure 1 – Biogas production across european countries [7][8]

Even if Romania is still at it's beginings relaed to the activities involving obtaining biogas from different types of residues, at the moment there are a number of projects in development for improving the general status of the country at this chapter. Connected with the existing types of residues, according to the National Waste Management Strategy all types of waste generated on the Romanian territory are classified as (i) municipal waste and similar, (ii) waste production and, (iii) waste generated from medical activities. According to statistics, in Romania, the total quantity of generated wastes has decreased by about 13% in 2003-2006 from 369.8 million tones to 320.6 million tones of wastes. In 2006 the amount of waste generated was : waste generated by mining and quarrying, 199.2 Mt, waste generated by other economic activities, 112.4 Mt, and municipal waste, 8.8 Mt. Recovery of industrial waste, both hazardous and dangerous, was approximately 12.5 Mt, which represented only 4% of total waste generated, the rest being eliminated. Of the total municipal waste generated, only 6.8 Mt were collected, meaning 76.8%. Household and similar waste represents 78.8% of the amount of municipal waste collected, and approximately 47% from those wastes are biodegradable, about 11% is both paper and cardboard, and glass, respectively. Only 0.6% from municipal wastes collected were recovered, 99.4% were removed through organized storage spaces (landfills). From household wastes, collected separately and recovered, almost 42% is paper wastes and cardboard, and 27% glass wastes.[9]

To Timisoara city, energy recovery from municipal waste could be a technical solution for long-term economic and social development. Waste collection and transport can be provided by the local health operator, and the incineration facility may be located and operated from a thermo-electric plant (eg : South CET Timisoara). According to data for 2008, the total quantity of waste collected, transported and stored was about 130.7 thousand tons. This is an annual quantity of waste per capita of 425.2 kg. The analyze of the development for waste composition and characteristics of Timisoara shows that by 2030 the total amount of municipal wastes will be ~ 144.6 thousand tons / year with an average low calorific value of 3500 kcal / kg.

Table 1 shows data on the forecast of population development over time, index generation and calorific value.

Table 1. Forecast of population over time, index and generating quantity and waste calorific value

Year	**2010**	**2020**	**2030**
Population [no. of people]	304314	295000	285000
Generating index [kg/people/day]	1.183	1.282	1.390
Generated quantity [t/year]	131401	138039	144595
Low calorific value for wastes in mixture [kcal/kg]	~2600	~3000	~3500

In the next figures there will be presented some details regarding the quantities and components of the collected municipal residues in Timisoara city.

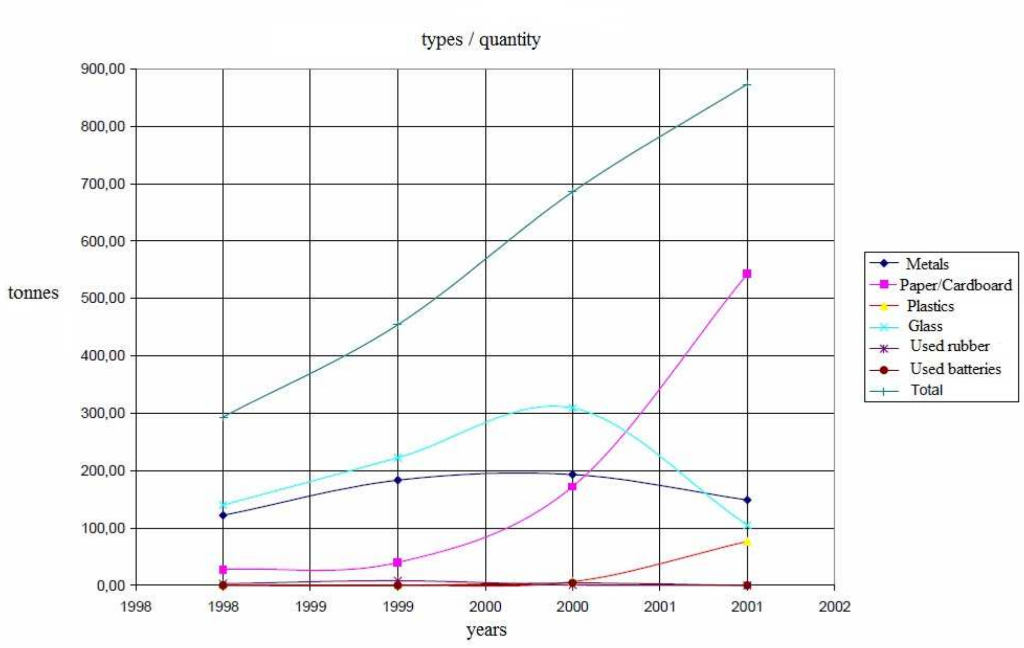

Figure 2 – The graphical repartition of the quantities and components for the collected municipal residues in Timisoara city between 1998 – 2001[10]

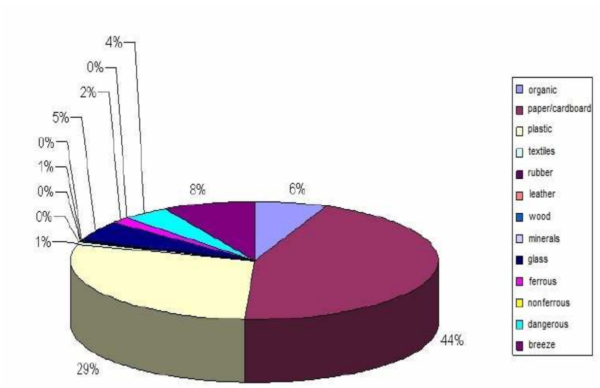

Figure 3 – Composition for the commercial and institutional residues in Timisoara city in April 2002[10]

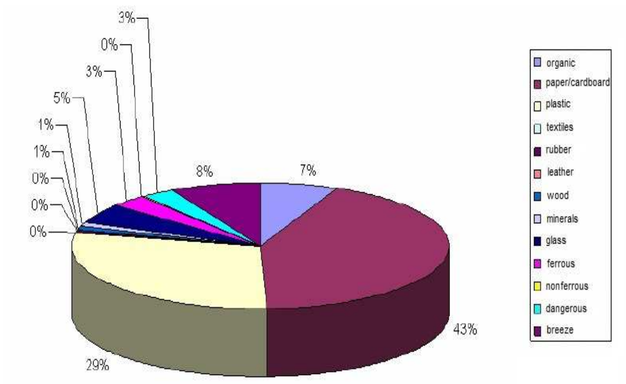

Figure 4 - Composition for the commercial and institutional residues in Timisoara city in October 2002[10]

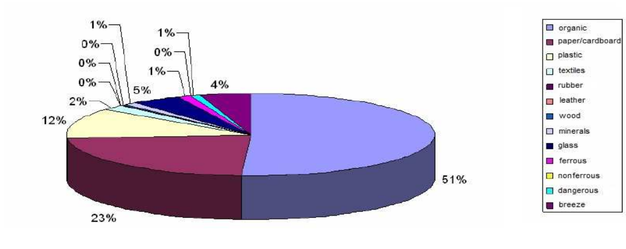

Figure 5 – Composition for the market residues in Timisoara city in April 2002[10]

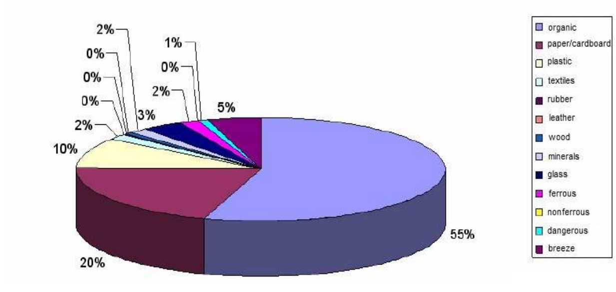

Figure 6 - Composition for the market residues in Timisoara city in October 2002[10]

2. Pilot plant for biogas from biomass residues. Discussion and applications.

One of the first steps there were made in the direction of using anaerobic fermentation in order to use the energetic potential of residues while producing biogas was the construction of a pilot plant at the “Politehnica” University of Timişoara, Fuel and Ecologic Investigation Laboratory, where investigations were made towards obtaining biogas using wood and agricultural residues.[11]

The schematics of the pilot plant are presented in Figure 7.

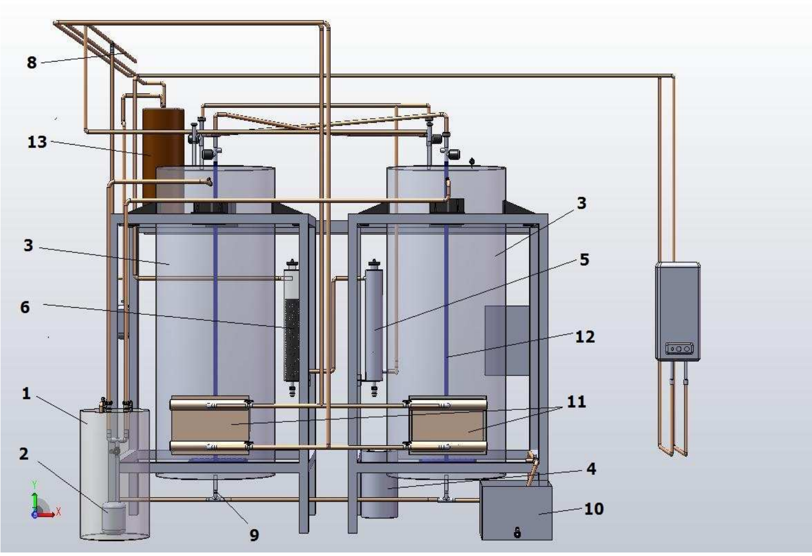

Figure 7 – Schematics for the pilot plant used for obtainig biogas from bioamss residues

From the biomass deposit, the used material is passed through a mill, and then it’s sent to the tank where the preparation of the suspension of biomass is made (1). The biomass suspension is transported with the help of the pump (2) and introduced into the fermentation reactors (3). The correction agent tank for the pH assures, through the control system, the conditions for the process of anaerobic fermentation. The resulted biogas is passed through a filter for retaining the H_2S (5) and after that, through a system used for retaining CO_2 (6), after which takes place the CO_2 desorption and the compression of the CO_2 in the adjacent system (7) and the purified biogas is sent for being used (8). The used material is discharged through the means of a gravimetric system (9), and the solid material is retained for being dried using the natural drying, and after that is sent to a compost deposit for being used as a soil fertilizer. A part of the resulting liquid is neutralized when the case, in the system (10) and sent to the sewerage network, or is transported by the recirculation pump (2) from the suspension preparation tank (1). The fermentation reactors are thermostat heated with the system (11). For the homogenization of the suspension is used a bubbling system (12) made by polypropylene pipes to avoid the possible corrosion. Also, for depositing small quantities of biogas of the purpose of analyzing, the installation is equipped with a small tank (13) positioned at the top of the reservoirs.

In Figure 8 is presented the principle scheme for the CO_2 retaining system.

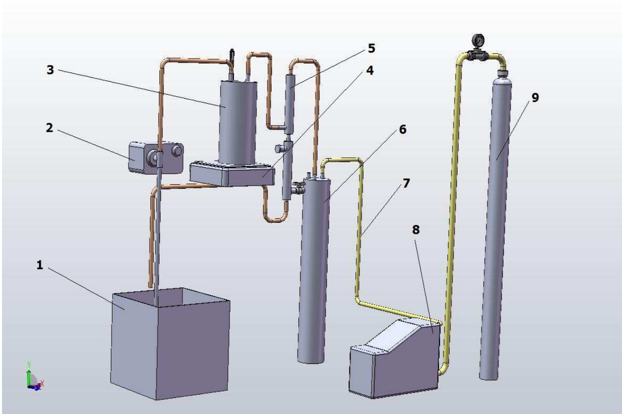

Figure 8 - Principle scheme for the CO_2 retaining system

The system is composed from a tank (1) from which the water is passed by the means of a dosing pump (2) similar with the dosing pumps used for the pH correction, a stainless steel tank (3) positioned on an heating device (4), a liquid separator (5), a buffer tank (6), from which the gas is aspirated with the help of a Haug compressor and inserted in a cylinder at a pressure of about 10 – 26 bar. The temperature inside the stainless steel tank can reach values of 50 – 60 °C.

With the help of this installation there were made some experimental analysis related to biogas quality and quantity using different sorts of wood and agricultural biomass residues.

In Figures 8 through 12 there will be presented some of the results connected with the quality of biogas in the main period of production for two different types of biomass residues: beech dust and a mix of maize and corn waste.

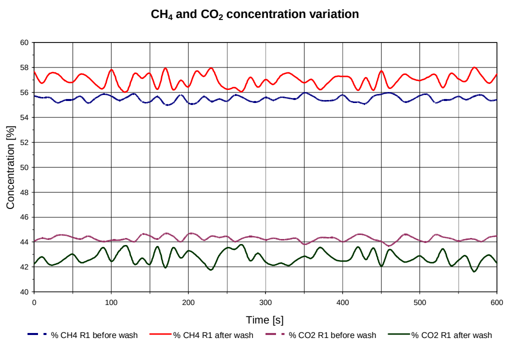

Figure 8 – CH_4 and CO_2 concentration: first reservoir, measurement no.2 – beech dust

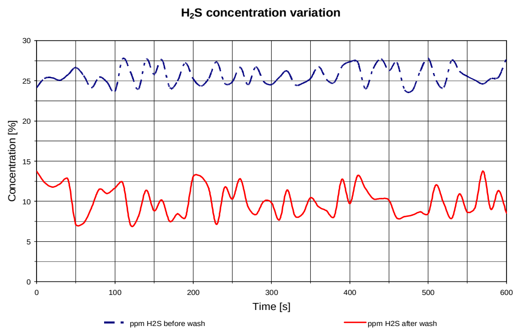

Figure 9 – H_2S concentration, first reservoir, measurement no.2 – beech dust

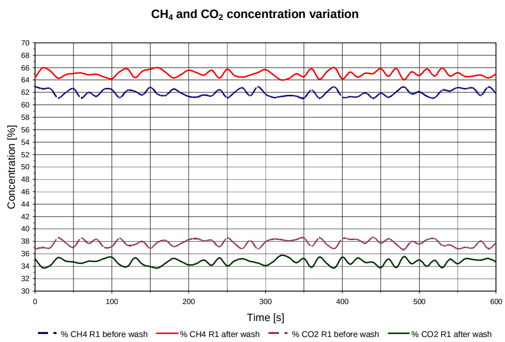

Figure 11 - CH_4 and CO_2 concentration: first reservoir, measurement no.2 - mix of maize and corn waste

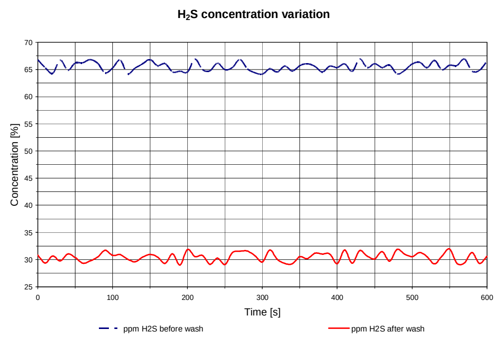

Figure 12 - H_2S concentration, first reservoir, measurement no.2 - mix of maize and corn waste

From the images there can be observed the variation of concentration for the main components of the biogas: methane, CO_2 and H_2S. After developing this pilot plant there was proposed the possibility of implementing another model of pilot plant using approximately a similar technology in order to use the potential of municipal residues.

3. Pilot Installation Description

As it was said in the previous chapter, one of the first steps there were made in the direction of using anaerobic fermentation in order to use the energetic potential of residues while producing biogas was the construction of a pilot plant at the “Politehnica” University of Timişoara, Fuel and Ecologic Investigation Laboratory, where investigations were made towards obtaining biogas using wood and agricultural residues [11].

Afterwards, inside the EPOC Project there was built one pilot plant with the potential to solve at least partially the problem of the increasing quantities of municipal residues.

Calculations of the facility are provided to SC COLTERM SA from Timisoara City Hall - Municipal Division - Service sanitation - Waste Management Bureau. According to data from the database of Timisoara City Hall, the quantity of the municipal residues collected, transported and stored in 2008 was 130,689 tonnes (870,420 m3) with a monthly variation from 8995 tonnes (February) to 12,778 tonnes (July). This represents an amount of 425.2 kg / inhabitant / year (1.165 kg / inhabitant / day) with a density of 150.14 kg/m3. Analysis of composition and evolution characteristics of Timisoara DSM was performed with the available data in the study by ADEME in 2000 and study by the University of Stuttgart in 2008.

The pilot plant using anaerobic fermentation of biodegradable waste from landfill is shown in Figure 7.

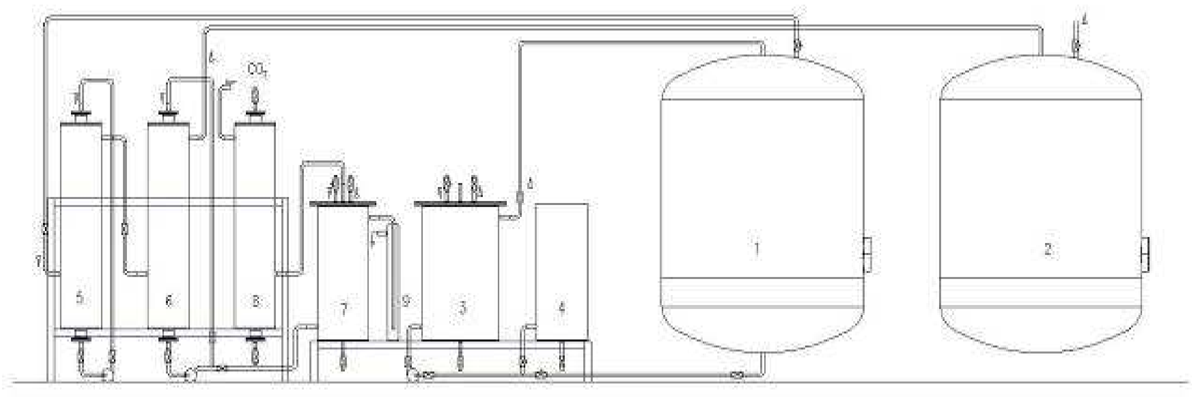

Figure 7 – Pilot plant using anaerobic fermentation of biodegradable waste from landfill - 1 – fermentation reactor; 2 – storage tank for purified gas; 3 – liquid solution recirculation tank; 4 – pH correction tank; 5 – H_2S filter; 6 – CO_2 filter; 7 – CO_2 evacuation tank; 8 – CO_2 buffer tank; 9 – hydraulic valve.

In Figures 8 and 9 are presented photos of the biogas pilot plant.

Figure 8 – Overall view of the pilot plant

Figure 9 – The adjacent system used for biogas cleaning and purification

The demonstrative pilot plant uses a cylindrical reactor, vertical, for methane fermentation. On the methane fermentation reactor's lid are placed connections for: pressure sensors, pressure gauge, exhaust of the biogas from the reactor until a minimum established pressure level, safety valve for evacuation in case of biogas accidental pressure increase. On the cylindrical virol of the reactor the following connections are located: pressure sensors, thermostat sheath for measuring and controlling the reactor temperature. At the bottom of the reactor there are pre-discharge (recirculation) connectors for the evacuation of the fermented liquid. From the reactor, the obtained biogas will pass through the purification system, where the CO_2 is captured and the concentration of H_2S is reduced to a value close to zero, and after that it will enter in the storage tank for the purified gas. From this point it can be used for different types of consumers according to the needs involved.

3. Conclusions

In Timisoara city there is a big potential of using the existing municipal residues in order to obtain clean technologies which are to be both cost effective and polution free. Those technologies are in accordance to national and international legislation and tendencies.

Obtaining biogas from anaerobic fermentation while using municipal residues appears to be one of the technologies that has the potential to solve at least partially the problem of growing quantities in municipal residues. The pilot plant developed inside the EPOC project (Energy for a clean city) is a solution regarding the degradable municipal residues and it can be used in parallel with other methods that use other categories of municipal residues that are not of degradable type.

The main component which results from the process is biogas, but as a secondary component which can be used, the residue obtained after the process can be used as a fertilizer for the agricultural surfaces.

The problem of sorting the municipal residues is not resolved entirely, but the implied efforts are significant. Those efforts involve the use of adequate technologies and installations.

Acknowledgement

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