THE INFLUENCE OF TEMPERATURE IN THE PROCESSES OF BIOLOGICAL ANAEROBIC TREATMENT OF THE WASTEWATER IN THE FOOD INDUSTRY

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Abstract

The purpose of this research is to supervise the efficiency of the anaerobe digestion using a fresh substratum with an organic charge expressed through CCO cr=6400mg/l, which comes from a food industry complex, for the same time of hydraulic retention but at different working temperatures. During the experiment the two reactors were loaded with the material which comes from an industrial complex which collected the waste water from a beer factory, a distillery and a juice factory. The fresh substratum with an organic charge expressed through CCOcr=6400mg/l, which comes from a food industry complex was placed in two reactors, each of them with a volume of 5 l. The working temperature was between 40-45 C and the hydraulic retention time of 10 days. The following parameters were supervised: the pH, the concentration CCOcr of effluent and the production of the obtained biogas.

Key words: wastewater, biogas, food industry, anaerobic treatment

INTRODUCTION

The food industry uses a large amount of water and the health and diet of the population depends on its way of functioning. So that a high consume of water, its impurity with a large amount of polluted substances , has negative effects upon the environment which, if not controlled in time, could produce a natural lack of balance with a great impact upon life in general.

The management of residual water and of the waste products which come from the technological flow became an important economical factor and an outstanding problem in the process of exploitation of the factories in the food industry. That is why many countries are interested in a rigorous management of the wastewater, in their epuration technologies and also in the possibility of using their organic potential as a source of unconventional energy.

The anaerobe degradation is proposed as an alternative to the treatment of the liquid residue with a medium and high organic charge.

The following organic waste products can be processed through anaerobe digestion: industrial waste products, slaughter houses, fruit, vegetables, agricultural biomass (Badea Gh., Paşca Daniela, 2006; Driessen, W.,Yspeert, P., 1999).

The biological anaerobe treatment, which was considered at first as a unique biological step, has been transformed lately in a step of biological pre-treatment, due to its advantages and disadvantages.

The wastewater from the food industry can be treated through anaerobe digestion because it has a biodegraded organic charge, enough alkalinity, phosphorus, nitrogen and micronutrients.

This process can guarantee the decrease of the organic substances with 70-90 %, mainly of the dissolved organic substances, which ensures the significant decrease of the biological anaerobe treatment level for the wastewater with a medium and high organic charge.

During the anaerobe fermentation processes, the macro molecular substances resulted from organic residue , the polysaccharides (cellulose, hemicellulose etc), the proteins and fats, when in contact with extracellular enzymes (cellulase, hemicellulase, protease etc) are decomposed in simple molecules (glucose or other sugar products, amino-acids, volatile fat acids, water and other micro molecular organic products), after which, with the help of bacteria, the process of decomposing continues by forming the reduced organic acids (the formic and acetous acid), carbon dioxide, hydrogen and water.

About 3% of the organic mass is converted into cellular mass during the anaerobe systems, the rest of 97% being transformed through catabolism in CH_4 and CO_2 (Baere, L.D., 2000; Rittmann, B.E. et al., 2001). The methane fermentation of the liquid and solid residue is an anaerobe process which ensures the progressive mineralization of the organic substances due to the oxidation-reduction biochemical processes and leads, on one side to the formation of carbon dioxide, and on the other side to the formation of methane through reduction. During this fermentation process, the mixed gas which is formed is known as the methane fermentation gas, pond gas or biogas (Alexei Atudorei, 1990; Badea Gh., Paşca Daniela, 2006).

The anaerobe processes take place in nature at a temperature between 0-97^{o}C. There were identified three different working domains in the anaerobe reactors according to the working temperature:

● the area of low temperatures(under 15^{o}C), where the psychrophilic bacteria exist;

● the area of moderate temperature (15-43^{o}C), where the mesophilic bacteria exist;

● the area of high temperatures (44-60^{o}C), where the thermophilic bacteria exist (Callender I.J, Barford J.P., 1983; Hobson, P.N., Wheatley, A.D., 1993).

The sensitivity to the environment temperature depends on different factors, especially on the degree of adaptation of the culture, on the operation mode and on the type of bioreactor.

The necessary time for the psychrophilic fermentation is more than 90 days, for the mesophilic digestion one 20-25 days, and for the thermophilic one 5-7 days. A sudden increase of temperature in the thermophilic medium takes to an important decrease of the gas production (Mirel I., et al., 2006).

The metabolism and the methanogenetic bacteria production ratio are influenced by the sudden decrease of temperature, so that it is advisable that during the anaerobe treatment to maintain a constant or almost constant temperature.

The treatment of the wastewater at high temperature increases the quantity of the produced gases, decreases the length of the process, increases the quantity of the decomposed organic substances with 5-10 %, but also decreasing the pathological bacteria.

The wastewater from the food industry can be treated by anaerobe digestion, because it has a biodegraded organic charge, enough alkalinity, adequate concentrations of phosphorus, nitrogen and micronutrients. The anaerobe treatment of the residual water happens without warmth transfer from the reaction, the heating of the substratum until it gets the temperature of the reaction being the essential request for the process.

During the anaerobe processes we have to ensure an adequate mixture among the involved elements in the transfer processes of mass and energy. It is also necessary to forecast the rapid release of the gas products to avoid the risk that the 'liquid surface catalysts" to be blocked by the gas bubbles (Angelidaki, I., 1992).

The physical and chemical factors affect the habitat of the microorganisms and the consistency of the processes of anaerobe treatment.

The temperature is considered one of the important factors for the proper functioning of the anaerobe processes, the metabolism, the reproduction capacity of the methanogenic bacteria and the fermentation length, the quantity and the quality of the produced gas depending on it.

According to the research information there was noticed that the increase of the temperature generates the increase of the gases production, but their content in methane can not surpass a maximum limit (Popescu Daniela Cornelia, 2006).

A major environmental benefit of the anaerobic digestion process is the production of biogas, a renewable energy source, which can be used as vehicle fuel, for heating and for electricity production. The treatment of the wastewater at higher temperatures increases the quantity of the produced gases, decreases the length of the process, increase the quantity of decomposed organic substances with 5-10%, also reducing the pathological bacteria.

In order to demonstrate this phenomenon there are two reactors with a capacity of 5 liters which are used simultaneously, but they operate at different temperatures.

MATERIAL AND METHODS

The fresh substratum with an organic charge expressed by CCO_{Cr}= 6400 mg/l, which comes from a food industrial complex, was loaded in digesters daily. The process of anaerobe degradation takes place in two reactors. Each of the two reactors (1) and (2) has a total volume of 5 liters. The working temperature was between 40-55^{o}C and the hydraulic retention time of 10 days.

During the experiment the two reactors were loaded with material which comes from an industrial complex which collected the wastewater from a beer factory, a distillery and a juice factory. The following parameters were supervised: the pH, the concentration of the effluent CCO_{Cr} and the production of the obtained gas.

Fig. 1 The working installation

RESULTS AND DISCUSSION

The temperature has an important role in the anaerobic biological processes. The efficiency of the process compared to the degree of the removal of the biodegraded polluting factors and to the quantity and quality of the obtained biogas and also to the length of the process, depend on the working temperature.
The results were summarized in the following table:

Table1.
The monitoring process which took place at different working temperatures (the arithmetic average of the obtained values on the monitoring period)

Working temperature(^{o}C)	CCO_{Cr}mg/l	The removal degree for CCO_{Cr}(%)	The biogas production, l/day
40	1536	75	3.7
45	1408	78	4.4
50	1216	82	5.2
55	1472	77	3.4

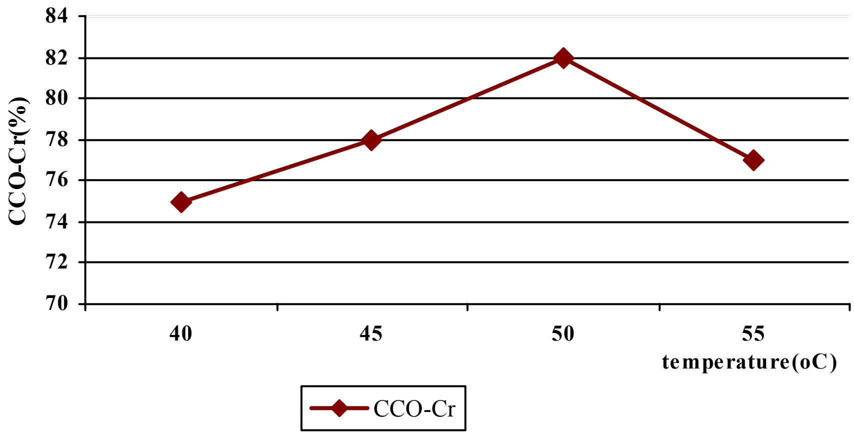

Fig. 2. The evolution of the removal degree for CCO_{Cr} according to temperature

From figure 2 we can notice that the operation temperature influences the performances of the biological anaerobe process. There was noticed that by determining the parameter of the CCO_{Cr} at different working temperatures between 40-55C, the maximum efficiency of CCO_{Cr} removal, 82%, was obtained when the digester operates at 50^{o}C, at a hydraulic retention time of 10 days. The increase of the temperature determines the increase of the degree of the removal of the polluting factors expressed through CCO_{Cr}, but this is valid only until the temperature of 50^{o}C.When the temperature is 55^{o}C, there can be noticed that the degree of the reduction of the organic charge expressed through CCO_{Cr} decreased at 77%.

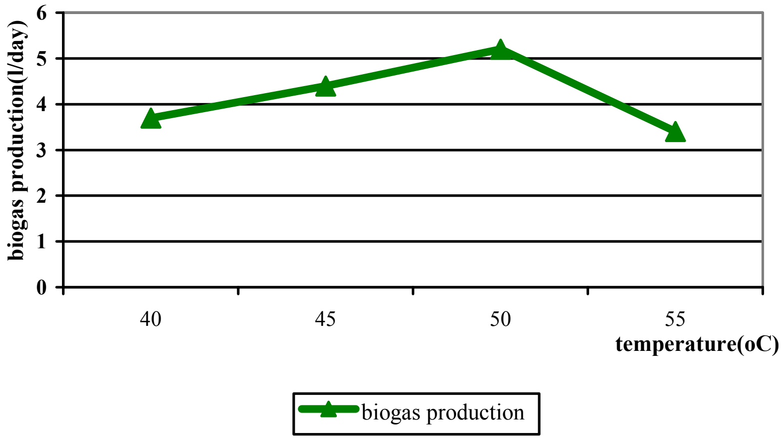

Fig. 3. The biogas production obtained at different working temperatures

From the previous representation there can be seen that the biogas production obtained in anaerobic digesters depends on the working temperature and on the hydraulic retention time. The largest quantity of biogas is obtained at an operation temperature of the digester of 50^{o}C. If we adopt the same time of hydraulic retention, at a temperature between 40-50^{o}C there was noticed an increase of the quantity of biogas obtained due to the increase of the temperature, but at 55^{o}C, it decreased.

The methane production obtained at 50^{o}C under the influence of the thermophilic bacteria is about the same with that realised by the bacteria developed in the mesophilic domain at temperatures of 20^{o}C and 30^{o}C, but after a longer period of time (Masse, D.I., et.al., 2001).

Even if the thermophilic process offers many advantages, the physical, chemical and biological characteristics of it are not known enough (van Lier, J.B., et. al., 1997).

CONCLUSIONS

The research revealed the fact that the temperature has an important impact in the variation of the biological and physical factors in the process of anaerobe conversion. The metabolism and the degree of production of the methanogenic bacteria are influenced by the sudden decreases of temperature, so that it is advisable that during the anaerobe treatment to maintain a constant or almost constant temperature.

The thermophilic and mesophilic digestion ensures the largest amount of the obtained biogas and the highest degree of the removed CCO_{Cr}. The high speed of degradation at thermophilic temperatures represents a possible advantage compared to the common mesophilic process, when the residual water has a high temperature.

This could be an advantage, from the economical point of view, in the case of the industries which should cool water until a temperature specific to the conventional process of treatment. An effluent with high qualities is obtained together with the increase of the temperature and it increases the amount of the obtained biogas, but only in specific environmental and operation conditions of the process.

As it can be seen from the present research, the increase of the temperature favored both the degree of removal of CCO_{Cr} and the quantity of the obtained biogas, but the temperature transfer from 50 to 55^oC had, as a consequence, a lower efficiency as regarding the decrease of the CCO_{Cr} and the reduction of the biogas quantity.

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