THE INFLUENCE OF HYDRAULIC RETENTION TIME ON THERMOPHILIC ANAEROBIC DIGESTION

Pantea Emilia*, Ghergheleş Carmen*, Romocea Tamara*

***** University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048, Oradea, Romania, e-mail: panteaemilia@yahoo.com

Abstract

The study focuses on the most appropriate technology to remove existing pollutants in the food wastewater and aims to identify the main methods for recovery of organic loading them as a source of renewable energy, therefore reducing energy costs, but also negative effects that ineffective treatment would have on the environment. It was determined the amount of biogas produced from food wastewater in reactors in series, each having a volume of 5 l. The digesters were fed with the mix wastewater from the food industry. The experiment takes place by supplying two reactors with wastewater from the food industry for different hydraulic retention time and operating temperature of 55°C. The amount of biogas obtained for the same hydraulic retention time for both reactors is higher than in case the reactors operates with different hydraulic retention time.

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

INTRODUCTION

Implementation of ISO 14001 certification and more stringent environmental legislation have been an important driver for the food industry to invest in biological effluent treatment (Driessen W., Vereijken T., 2003).

Anaerobic biodigestia may be an option to the biological wastewater treatment, being configured as an important energy carrier able to provide heat and electricity with efficient removal of organic matter, production of biofertilizers and to reduce pathogenic microorganisms (thermophilic field) (Tentscher, W.A.K., 1995).

Anaerobic degradation is proposed as an alternative for wastewater treatment with a high and average organic load. The anaerobic digestion can be processed as various organic wastes: industrial waste, slaughterhouses, fruit, vegetables, agricultural biomass (Banks, C.J., et.al., 1999, Mirel I., et. al., 2008).

Wastewater from food industry can be treated by anaerobic digestion, as it has an organic biodegradable load, sufficient alkalinity, adequate levels of phosphorus, nitrogen and micronutrients (Hobson, P.N., Wheatley, A.D., 1993).

The process of anaerobic digestion (AD) employs specialized bacteria to break down organic waste, converting it into biogas, a mixture of carbon dioxide and methane, and a stable biomass.

Under anaerobic conditions, a considerable portion of the chemical oxygen demand (COD) is converted into methane gas as an end product.

Methane is a potential energy source, thereby considerably lessening the requirements regarding the waste biomass disposal and the financial burden associated with disposal (Usama Zaher, et al., 2007).

Biogas is a mixture of gases generated by a complex process of degradation of organic matter under anaerobic conditions using a variety of microorganisms (Bernd Linke, 2006).

Biogas produced from AD has been promoted as part of the solution to energy problems. Methane contains about 90% of the energy with a calorific value of 9000 kcal /m^3 and can be burned on site to provide heat for digesters or to generate electricity (Tentscher, W.A.K., 1995).

Due to the need for energy, thermophilic biological treatment is advantageous for industries that generate wastewater with high temperature whose cooling is needed; the application of this technology is an effective alternative in terms of economic and energy consumption (Jung Kon Kim et al., 2006).

MATERIAL AND METHOD

With the aim to accomplish the research topics related to this work, experiments were performed in the laboratory of the physico-chemical analysis within the Faculty of Environmental Protection Oradea, during January – April 2010.

The main purpose of our work was to research the feasibility of the biological process with fixed biomass for wastewater treatment with medium and high organic loads in thermophilic anaerobic conditions by separating the two phases defining the process: acidogenesis and methanogenesis.

Hydraulic loading rate applied to anaerobic system influence the stability and performance of process as one of its key factors. The contact time required to achieve biochemical decomposition depends on the complexity of the substrate to be treated. The process can be demonstrated by different hydraulic loading of two reactors in series: acidogenic phase is conducted in the first reactor, that methanogenesis, in the second reactor.

During the process, two reactors were fed with material from an industrial complex that collects wastewater generated by a brewery, distillery and a soft drink factory. Biogas produced in reactors (**1**) and (**2**) was collected in collecting tanks of gas with a volume of 5 liters (**3**) and (**4**).

Fig. 1. The work installation

The gas production obtained in the digester was measured daily. Daily parameters were also determined: pH and COD. To maintain the pH within the limits necessary for the development of methanogenic microorganisms, a solution of sodium bicarbonate, $NaHCO_3$, 30% was prepared during the experiment. Its determination was performed using a portable pH meter Hanna Instruments, HI 98127. The COD determination in water was oxidized with potassium dichromate in hot sulfuric acid medium and the excess dichromate was titrated with Mohr salt in the presence of ferine as an indicator (American Public Health Association, 1990). The reactors temperature was maintained at 55^{o}C and biogas generated was collected in collecting tanks of gas (3) and (4).

RESULTS AND DISCUSSION

Anaerobic treatment systems are separate main phases of the degradation of organic compounds which have advantages over conventional ones because they allow the selection and development of microorganisms. In the first phase, organic polymers are degraded by acidogenic bacteria into volatile fatty acids that are converted by acetogenic and methanogenic bacteria into biogas in the second stage. Hydraulic retention time is directly correlated with hydraulic transit, which is one of the key factors of anaerobic process.

The performance of anaerobic processes is presented in the following table:

Table 1

Influence of hydraulic retention time on quantity of biogas

Reactor	Acidogenic (1)	Methanogenic (2)	Acidogenic (1)	Methanogenic (2)
Hydraulic retention time (days)	2	4	4	4
Organic loading g.l-1.day	9,47	2,83	3,98	2,70
COD removed (%)	31,9	61,5	30,1	71,7
pH	5,4	7,6	5,5	7,8
Biogas l/l.day reactor	0,285	0,320	0,182	0,455

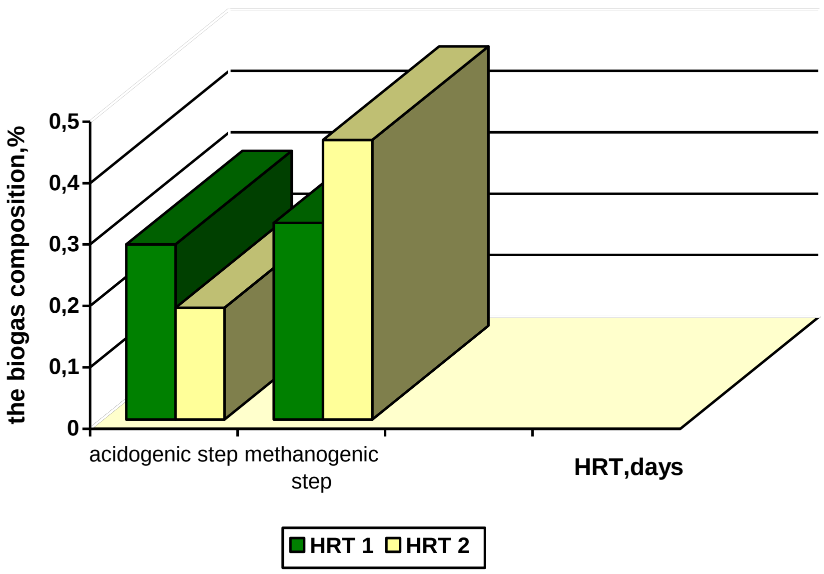

Fig. 2. The amount of biogas obtained

It was noted that the maximum reported efficiency of COD removal rate (71.7%) was obtained when the two digesters were operating at the same hydraulic retention time. Moreover, the operation of two reactors at the same hydraulic retention time (4 days) leads to a greater quantity of biogas in the methanogenic stage.

One of the most important environmental factors associated with the optimization of methane production in anaerobic biogas is pH. Anaerobic digestion of industrial wastewater is achieved in the pH range between 6 and 8; significant problems are seen when the quality of processed wastewater and biogas production decreases for pH values lower than 6.

CONCLUSIONS

The usage of anaerobic reactor that separates the two stages of anaerobic degradation (bacteria growth on inert supports) allows more time to maintain the biomass in the reactor, increasing the efficiency. It also increases the process stability by controlling the acidogenic phase.

The first filter acts as a metabolic buffer, preventing pH shock, high rates of organic loading. The amount of biogas produced increases with the increment of hydraulic retention time applied to the two reactors.

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