ANAEROBIC BIOCONVERSION OF URBAN WASTEWATERS - SOURCE OF GREEN ENERGY

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Abstract

This paper aims at applying the technology of anaerobic treatment of wastewater collected from Oradea. The objective of this research was to identify the optimal conditions for biogas production by processing the mechanical stage effluent of the wastewater treatment plant of Oradea. The experiments were carried out in a laboratory on a system consisting of two bioreactors with a capacity of 11 litres. The operating temperature range is specific to mesophilic area, v 35 -37 ° C). The biogas conditions were monitored such as pH, working temperature, organic loading rate. The results showed that biogas was generated with a methane concentration of 45% for 25 days, and working pH of 7.2. COD removal efficiency was of 58.7%.

Keywords: *biogas, urban wastewater, anaerobic digestion*

INTRODUCTION

Due to the increasing world population and other factors, fewer people benefit from drinking water. The water problem can be solved by increased production, better distribution and saving existing resources. For this reason, water is a strategic resource for many countries, essential for sustaining human life and all life forms on earth. During the development of mankind water plays a crucial role with great impact in all areas of activity. Between water, man and civilization there is a connection. The great ancient civilizations developed on the banks of the Nile, Tigris, Euphrates in Mesopotamia, Indus, Ganges and the Yellow River in India and Huang He in China (Danquah et. al., 2011). "Yet much attention has not been devoted to adequately protect this all-important resource. This is confirmed by the fact that about 2 million tons of waste are disposed off within receiving waters daily" (UNESCO-WWAP, 2003).

Sustainable development is the foundation for global economic growth of this century by the reduction of resources, the world has focused its efforts on bioenergy production from renewable sources, and when it is associated with protection of water resources by urban wastewater treatment the environment pollution will be reduced. Wastewater treatment processes can be physical, chemical, biological or combined. These methods are combined, because only thus can be achieved the levels of treatment required by environmental regulations (Pantea, 2010)

Therefore, wastewater discharge into the environment must be done in such a manner so that it does not affect their subsequent use. The quality of water discharged depends on the treatment technologies adopted and their establishing is based on the physical, chemical, biological and bacteriological of wastewater and considering the quality categories of emissaries. “The management with this appropriate technology can decrease an environmental problem, as well as reduce the global warming. Achieving solutions to possible shortage in fossil fuels and environmental problems that the world is facing today requires long-term potential actions for sustainable development” (Jiang et al,).

. From this point of view, the most effective solutions in wastewater management should take into account both the reduction of pollutant load of wastewater, and the opportunity to exploit them as a source of renewable energy. Harnessing the biogenic potential of wastewater, sludge, manure is not a recent technology, being successfully applied many years ago in countries like India, China (Jiang et al,).

One of the most challenging options is the anaerobic biological treatment, a technology that generates bioenergy (biogas), and it may allow a reduction in pollutant load of wastewater (Pantea, 2010). This technology is successfully applied in treating wastewater coming from food, fermentation sludge, digestion wastes etc. (Kafle et.al, 2013). At the level of city treatment plants this technology is applied for fermentation of sludge.

The biogas production mechanisms are composed of acidogenesis and methanogenesis processes through anaerobic digestion of organic matter” (McCarty, 1964). “In general, all types of wastewater can be used as substrates as long as they contain carbohydrates, proteins, fats, cellulose and hemicelluloses as main components”(www.intechopen.com).

The procedures for conducting the process for the conversion of these organic polymers to biogas, depend on a number of operating factors, as well as the environment (pH, temperature etc.) (Chae et al., 2007).The main products of anaerobic digestion are: biogas, the effluent stabilized, a kind of sludge with improved properties.

Biogas is a gaseous mixture consisting primarily of methane, carbon dioxide, and in small proportion gases such as: H_2S, H_2, NH_3 etc. The amount and composition of fermentation gas (biogas) is dependent on the organic composition of the material subjected to degradation and to the process operation. For an anaerobic decomposition of carbon hydrates a biogas is formed with a composition of $CH_4/CO_2 = 1/1$. This ration can advance to $CH_4/CO_2 = 2/1$, depending on the ratio of carbon-rich proteins and fats.

Anaerobic effluent characteristics depend on the type of system adopted for treating wastewater and their organic load. During the anaerobic process a part of the organic matter is converted to methane, but some is digested and is recovered in the effluent. Anaerobic digestion provides a sludge in a smaller amount compared to the aerobic treatment, with good qualities to be used as a fertilizer for agriculture. This sludge contains nutrients (N, P, Mg, etc.) (Igoni et. al., 2008).

MATERIAL AND METHODS

The main specific objectives of this research are:

- estimate the anaerobic digestion efficiency in terms of reducing the organic load (expressed as COD) of urban wastewater, working in the mesophilic field and monitoring the parameters that influence this process;
- estimate the biogas production.

The material needed for processing was the effluent coming from the mechanical stage of the wastewater treatment plant collected from Oradea and adjacent communes. The wastewater treatment plant is mechanical-biological type and plant effluent is discharged into the Crișul Repede river. The mechanical biological treatment ability of the wastewater treatment plant is 2.200 l/s.

The technological flow on the water line, is made up of:

- mechanical stage: input room, rare and dense grids, sand trap, fat separator, primary clarifiers, primary sludge pumping station;
- Bbiological stage: aeration tanks, secondary clarifiers, activated sludge pumping station, extra sludge storage tanks, biological exhaust channel station.
- chemical stage: P_t reduction.

Since the purpose of this paper is the study of the possibility of introducing in the technological flux of urban wastewater treatment of a anaerobic biological stage, the wastewater needed initially was taken from the mechanical stage effluent of the municipal treatment plant.

In order to highlight the water quality the following determinations were done: pH (pH meter WTW), COD, N_t, P_t (Photometric Hanna HI 83224) for mechanical effluent, but also for anaerobic effluent, collected after passing through the anaerobic digester. To maintain the pH within the limits necessary for the development of methanogenic microorganisms, during the experiment, it was prepared a solution of sodium bicarbonate, $NaHCO_3$ 30%. Temperature was between 35-37^o C and hydraulic retention time of 7 days. Anaerobic digester is a device belonging to the Department of Environmental Engineering, Faculty of Environmental Protection that can provide information on the energy potential of organic masses processed in anaerobic processes.

Fig.1. The installation of anaerobic digestion

RESULTS AND DISCUSSION

Control parameters and the performance of the anaerobic processes are shown in the following table:

Table 1

Monitoring of the process (arithmetic mean of the values obtined during monitoring)

INDICATOR	UM	Treated mechanically	Anaerobic effluent	Values admitted for evacuation	Ratio of removal (%)
		Average concentration	Average concentration		
pH	unit pH	7,19	7,54	accepted	-
COD	mg / l	287	63,14	125	**78**
Total nitrogen	mg / l	26,0	11,7	10	**55**
Total phosphorous	mg / l	4,32	2,54	1	**41**

The production of biogas obtained during the course of the experiment was: 1.7 l.

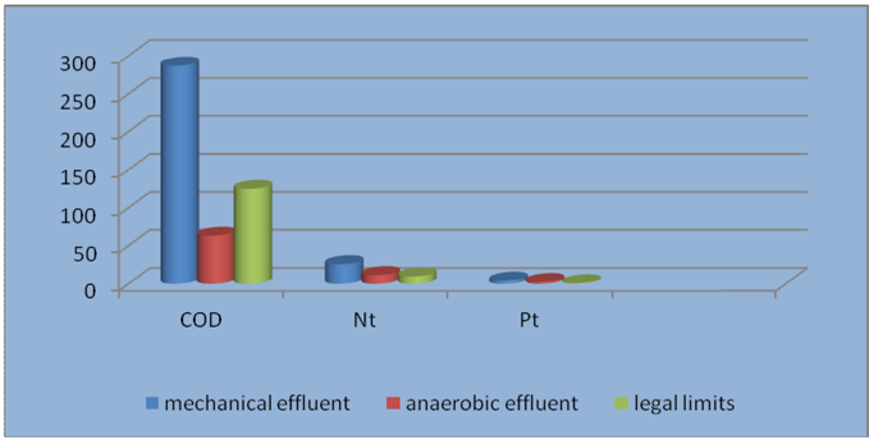

Fig.2. Monitoring of the process

As it can be seen from the data presented above, applying the technology of anaerobic biological treatment of urban waste water after the mechanical stage it proves that in terms of COD parameter, we get its significant reduction, 78% (Directive 91/271/EEC - 75%), but much lower for nitrogen and phosphor, 55%, respectively 41%. Because, according to the legal national and international recommendations in force (Directive 91/271/EEC, respectively HG.188/2002, as amended by HG 352/11.05.2005), the legally admissible limits for total nitrogen and total phosphorus are 10 mg/l and 1 mg/l, and the results obtained in the laboratory led to the values of these parameters 11.7mg/L (N_t) and 2.54 mg/l (Pt) it is necessary to apply an aerobic stage which allows the reduction of nutrients, eliminating the danger of eutrophication phenomena in the emissary. The amount of biogas produced in working conditions applied in this study is small, and the application of this anaerobic technique in the water flow would not bring a significant amount of energy.

CONCLUSIONS

The possibility of replacing primary decantation with an anaerobic digester biogas, is an environmentally friendly alternative which provides a new source of energy. Introducing a stage of anaerobic pre-treatment followed by aerobic biological treatment in order to reduce nutrients is a challenge for sustainable management of wastewater. Anaerobic biodigestion may be an option for biological treatment of wastewater, being configured as an important energy carrier capable of providing heat and electricity with efficient removal of organic matter, production of biofertilizers and reduction of pathogenic microorganisms.

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