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Possibilities for the development of an energetic bioreactor from organic residues

Posibilidades para la implementación de un biorreactor a partir de residuos orgánicos

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Abstract

This research presents the possibilities for the development of a reactor for the generation of electrical energy with the use of organic residues is presented. In this sense, the plan for this research is to make a physico-chemical characterization of the input material as well as for

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the output gas which is produced. Afterwards, thermodynamical analysis of the electrical potential of this produced gas is done.

Keywords: Energy reactor, Gas production, Sustainable development, Clean energy.

Resumen

Esta investigación presenta las posibilidades para el desarrollo de un reactor para la generación de energía eléctrica con el uso de residuos orgánicos. En este sentido, el plan para esta investigación es realizar una caracterización físico-química del material de entrada así como al gas de salida producido. Posteriormente, un análisis termodinámico del potencial eléctrico de este gas producido se realiza.

Palabras clave: Reactor de energía, Producción de gas, Desarrollo sostenible, Energías limpias.

1. Introduction

Guaranteeing enough quality food for the growing global population, currently 8 thousand million of inhabitants [1], have led to the grow of food production. This fact has originated great challenges of environmental conservation, process optimization, social and economical impact in all stages of the productive chain [2]. A balanced diet for the population implies abundant quantities of nutrients (carbohydrates, lipids, and proteins) in food. Carbohydrates are present in most of the vegetal based food, making them accessible and abundant.

As well, fats can be of animal or vegetal origin, so the availability of these macronutrients satisfies the necessity of these groups [3].

In contrast, despite proteins can be found in food as legumes, their principal consumption is associated with animal production, constituting one of the great challenges of the food industry [4], since the production of meat causes a great deterioration to the environment. In this sense, it is necessary to implement a circular economy in obtaining protein from animal sources to meet the demand of this type of food with the least possible impact [5-6].

There are several sources of obtaining animal protein, among them those produced by the pig and bovine poultry [7] industries stand out. In the livestock industry, it has great challenges associated with the use of organic waste that it generates and the reduction of greenhouse gas emissions that it produces and the large consumption of water resources [8]. An opportunity to mitigate these effects is the use and recovery of organic waste, to use it as fuel source and in this way, they can be integrated into a regeneration cycle in their production processes, helping to promote energy transition processes [9]. All the above is accelerated by the data on the increase in greenhouse gases, which has prompted more awareness of the preservation of nature and the new legislation issued in the United Nations assembly for the minimization of climate change [10].

Additionally, in cattle farms and surrounding communities, as they are located in remote rural areas, an additional problem has been found associated with the use of firewood from trees to obtain energy [11], since it does not have access to natural gas distribution networks; and obtaining propane gas cylinders is difficult due to access and in some cases due to the limited purchasing power of the peasants. This problem increases deforestation; it should be noted that the livestock industry already produces a large amount of deforestation [12], making it pertinent to search for alternatives that not only promote the reduction of logging in rural areas of the department, but also allow that use of the waste associated with livestock activity as an energy vector for these rural areas and the generation of products that can be fertilizers for reforestation.

2. Biodigesters

The use of biodigesters has become the best option for the transformation of raw material waste for the generation of energy such as natural gas (methane), liquid organic fertilizers (biol) and solids [12]. In this way, this research proposes the study of different residues from agricultural industry in three different rural areas of the department of Bolívar to take advantage of bovine, swine, poultry feces and organic waste from agriculture; as substrates to be processed in three different biodigesters, one for each zone, one for each zone, in order to evaluate the biogas production capacity, as well as the obtaining of biotechnological by-products such as liquid and solid fertilizers that result from bio digestion. This study would make it possible to generate comprehensive strategies that contribute to the objectives of energy transition and reduction of the negative impact on the environment, helping to fulfill the commitments acquired by the country regarding the objectives of sustainable development through the implementation of circular economic systems in rural areas and the use of alternative energy for production processes.

3. Methodology

3.1. Generation of processes

Training of engineering students for developing activities to facilitates sample obtention, as well as analysis, modeling, elaboration, and start-up of the biodigesters is included as a fundamental part of the project. Three biodigesters for three farms will be implemented, which results will be collected, analyzed, and correlated. This is a work for strengthening social projection of the academic field, proposing alternatives to the problems of communities in the region.

3.2. Characterization of organic residues from farms

3.2.1. Physico-chemical and biological characterization of the organic residues

The nutritional content of the biomass fed to the biodigester is key to the bacterial metabolism with which biogas is produced. Therefore, initially it is necessary to carry out a physicochemical and biological characterization of fresh residues, where the tests considered are:

a. **Physicochemical characterization:** Element analysis is performed to obtain carbon, hydrogen, oxygen and nitrogen composition by means of a Sundy SDCHN435 element analyzer. For the bromatological analysis, moisture (AOAC 930.15), crude protein (AOAC 2001.11), neutral detergent fiber (AOAC 2002.04), acid detergent fiber (AOAC 973.18), nitrogen linked to neutral detergent fiber, nitrogen linked to acid detergent fiber, ethereal extract (AOAC 920.39), digestible energy, non-protein nitrogen, ashes (AOAC 942.05), lignin AOAC 973.18 and, Ca and P (CIA-SC09-01-01-P10).
b. **Microbiologic analysis:** Microbiologic analysis contemplates the determination of total Coliforms and Escherichia Coli by means of the multiple tube dilution technique (NMP), Salmonella s.p.p. by means of Elisa Assay, Shigella by differential staining method in Xylose Agar Medium, molds, and yeasts by the plate count technique by deep sowing.
c. **Physicochemical analysis of process water:** The quality of water processing will be determined through the content of total solids (ST), volatile solids (SV), suspended solids (SS), total dissolved solids (SDT) by means of gravimetry, pH and conductivity by potentiometry, heavy metals by means of atomic absorption spectrometry, alkalinity, hardness, chlorides and phosphates by volumetric titration methods and turbidity by nephelometric method.

4. Bioreactor selection and ensemble design

4.1. Selection of the adequate biodigester type

From the carbon and nitrogen contents of the substrate, the matter balances, energy, and kinetics of hydrolysis, acidogenesis, acetogenesis and methanogenesis will be carried out, the mathematical model for the kinetics will be selected and with this result, the suitable type of biodigester will be chosen for each farm in order to obtain the mixing conditions of the feed of the biodigester and yield in biogas production to maximize methanogenesis.

4.2 Quality and quantity quantification of the obtained products

Biogas from the anaerobic digestion of biomass is considered an energy source with high economic and environmental potential, since in addition to energy use, its use can contribute to the mitigation of environmental pollution problems due to the use of organic waste, and at the same time to produce useful fertilizers for agricultural applications. To achieve high performance in the aspects, at this stage it is proposed to follow the following methodology:

A. Setting up the biodigester

During this stage, process variables such as retention times, temperature, agitation speed, pH, volumes of gas production and generated effluents, as well as their composition, must be monitored.

B. Biogas characterization

According to the changes made, the volumes of gas obtained will be determined. In addition, it will be characterized by means of gas chromatography, to determine the amount of methane, carbon dioxide, oxygen and nitrogen. The heat capacity, ignition temperature, adiabatic flame temperature will be quantified.

C. Characterization of subproducts

During the production of biogas from agricultural residues, liquid and solid bioles are obtained, which are rich in nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium and other important elements for plant nutrition. Following the methodology describe in the physicochemical and biological characterization of fresh residues, the by-products are characterized.

D. Plant automation

In the biodigester processes, biogas leaks typically occur, raising CH4 and CO2 pollution into the atmosphere and decreasing process performance with sulfur excess. One way to avoid these leaks is the implementation of an automated control system that guarantees the efficient and safe production of biogas. For this, all the information on the operation of the plant will be compiled to identify within the process, the critical points of gas leakage. Based on this information, a control system could be designed, considering the devices involved in the process (sensors, transducers, motors, drivers, etc.), measurable variables, control variables, operation ranges, devices operation, inputs and outputs.

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