Production of biogas from organic solid residues, by the use of biodigester in bench scale

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Abstract. The urban solid waste that is deposited in the open dumps generates great contamination during its decomposition stage since it undergoes different changes due to the action of the microorganisms that produce CO2, CH4 and other residual gases that affect the environment and health human. The present work aims to evaluate the efficiency of biogas production from organic solid wastes generated in the University Restaurant of the Technology Center of the Federal University of Rio de Janeiro through anaerobic digestion in biodigesters at scale bench. During this study an anaerobic digestion test was carried out in a bench scale biodigester for a period of 48 days, prepared with organic solid waste, anaerobic sludge and waste water; being analyzed and controlled different chemical parameters, besides the values of temperature and ph. The test prepared for this project consisted of 6% of total solids consisting of solid wastes, anaerobic sludge and wastewater, resulting in an efficiency of removal of total volatile solids of 55% and the production of approximately 38% CH4, 43% CO2 and 10% H2S.

1. Introduction
For years the generation of urban solid waste has increased in proportion to the growth and development of countries, impacting on natural resources (water, air and soil), as well as on the populations surrounding the places of deposit. In this way, many states are creating and implementing the Integral Solid Waste Management (ISWM) plan which is associated with the generation, storage, collection, transport, treatment and final disposal of urban solid waste, with the aim of avoiding diseases in addition to the environmental impact that this entails and with this to improve the environmental conditions that contracted the inadequate final disposition of these residues [1-5]. The ISWM seeks to be a successful, socially verifiable and economically sustainable management to achieve the maximum efficiency, minimum environmental, social and economic impact on the final disposition of solid urban waste [6].

Different studies have been carried out with the aim of minimizing the environmental problem caused by urban solid waste; Anaerobic digestion has been one of the main technologies used to treat organic waste, mainly because of its low cost of implementation as well as the possibility of generating energy and mitigating the gases generated by the decomposition of this waste [7-10].

The present work aims to evaluate the efficiency of biogas production from organic solid wastes generated in the University Restaurant of the Technology Center of the Federal University of Rio de Janeiro (UFRJ) through anaerobic digestion in biodigesters at scale bench. During this study an anaerobic digestion test was carried out in a bench scale biodigester for a period of 48 days, prepared...
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2. Materials and method
The solid waste collection process used for the present research study was carried out in the university restaurant of the technology center of the Federal University of Rio de Janeiro; the waste was classified with the objective of obtaining the pure organic matter, removing any type of material that could cause damage to the crushing equipment used for the next stage. The residues were then treated in a household blender to obtain a fully comminuted blend in order to reduce the size of the particles and favor the various stages of anaerobic digestion. The residues were placed in a completely clean container and taken to the refrigerator for later use. In this process 2 kg of solid waste plus sludge was used. For this study, sludge was used in its first stage of the process, this one was collected from the Rica Alimentos station located in Rio de Janeiro, this was conditioned in a plastic container and transported to the laboratory, and later the mud was located in the laboratory refrigerator with the objective of preserving its biological characteristics for later use.

The residual water used for this study was collected from the CDAE joy water treatment station located in Rio de Janeiro. This content was collected in a plastic container and transported to the laboratory, then placed in the laboratory refrigerator with the objective of preserving its biological characteristics for its use.

3. Results and discussion
The results obtained during the process of anaerobic digestion of urban solid waste in a bench scale biodigester are presented below. The experimental test was performed with proportions of 7% solid waste, 8% sludge and 85% residual water.

During the anaerobic digestion process carried out during this work the pH value was monitored daily, as shown in Figure 1; thus, when the pH values were outside the stipulated ranges this was adjusted by adding sodium hydroxide (NaOH) in order to obtain values in the range of 6 to 8 so as to allow a condition close to neutrality so favor the process of anaerobic digestion.

![Figure 1. pH monitoring and adjustment.](image)

According to [11] their study of the process of anaerobic digestion of organic solid waste and wastewater sludge; with total solids concentrations of 5%, obtained a 96% removal efficiency and 62% methane gas. Estoppey [12] obtained a volatile solid waste removal of 90% in the study with organic solid waste.

9% of the total fixed solids refer to inorganic matter that could not be transformed during the anaerobic digestion process due to the lack of non-degradable microorganisms in the substances, the increase of these solids is due to the reduction of the total volatile solids and shown in Figure 2.
The following are the values and the production of CH₄, CO₂ and the fractions of other gases as results of the experimental work carried out during the 48-day period; the biogas production was collected in Tedlar bags of 5 liters adjusted directly in the biodigester.

In the results obtained from the gases generated in the first 6 days of the process it can be observed that the CH₄ generation volume is 0% (Figure 3), this result is probably obtained because the process was in the early stages of anaerobic digestion and it is not possible to generate CH₄.

As a result of the anaerobic digestion process, approximately 20 liters of total biogas volume were obtained (Figure 4), in fractions of 38% methane gas, 43% carbon dioxide and 10% hydrogen sulphide.

From the obtained results it is possible to analyze the factors that possibly had influence in the production of biogas, the first and most important is the retention time since the hydrolysis stage in
which the monomers that favor the formation of CH₄ by acetogenic bacteria and acetoclastic methanogenic archaea did not have enough time to consume H₂.

Another factor that probably influences the results is the residual water that was used, which had a high degree of oil and fats that inhibits the formation of CH₄ and favors the formation of H₂S and CO₂; this also indicates that in order to maintain a good efficiency in the production of biogas, especially CH₄, the waste water needs to contain in its composition substances that complement the needs of the anaerobic microorganisms and / or maintain better conditions for the biodegradation of the constituents of the residue. It can be verified is the characteristic of the food residue, that is, it did not contain representatives of the whole microbial population necessary for the complete degradation of its constituents, allowing this and the production of methane to be slow and almost interrupted.

4. Conclusions
In this work, it was possible to verify the reduction of total volatile solids, which is one of the great problems that are experienced worldwide due to the considerable increase in the generation of organic solid waste and wastewater. This can lead to the implementation of biodigesters in large landfills to reduce pollution and produce energy. The inorganic matter of this process can be used with different treatments to be used as fertilizers and raw material from other processes. This project that is initially done at the laboratory level can be implemented on a larger scale by controlling the different operating parameters. This would serve to establish the basis of a society more committed to the environment with the hand of science and technology.

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