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Scaling a Biodigester Ascendant Flow for Biogas Production via Sewer and Solid Waste

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Abstract.

The residues originating from sewer pipes and urbane garbage need treatment before being discarded in the environment to avoid the contamination of grounds, water sheets and dissemination of diseases. Besides the bad smell and of being forts contaminants, these residues are still collaborators of the greenhouse effect due to the composition of the gases that comes from his decomposition. The high methane concentration in the composition of these gases favors the production of biogas, what can be converted in electric or thermal energy. The objective of this study is to conduct a case study of the implementation of a biodigester in a residential condominium, aiming for the treatment of the residues and use of a produced biogas, minimizing damage to the environment.

Key words

Biogas, Solid Waste, Biodigester, Sewage, Methane

1. Introduction

In the last years, the population growth in Brazil was dizzy. Between 2000 and 2013, the number of residences reached a total of 62,8 million, according to the IBGE. However, only 64,3 % of this total had sewage treatment. Of the total of residences, nearly 1 million they are in towns or in residential condominiums. Aiming at the decentralization of the cities, the phenomenon of the increase in the number of residences out of traditional housing sets offers a residential model –in the limited past to the high class – to the metropolitan regions, looking for bigger security and tranquility in front of the turbulent rhythm of the great metropolises.

The consequent reconfiguration of the city, allied to the unpublished urbane dispersal and to the rural exodus, developed the problematic picture of the essential public utilities, like the collection of garbage and the treatment of sanitary residues. There are more and more obvious the impacts of the growth messed up in the environment. The delay in the definition of laws that treat specifically the basic sanitation brought the lethargy in the introduction of the systems of urbane treatment and collection of residues.

Only in 2007, with the institution of national directives for the basic sanitation (Law no 11.445, of the 5th of January) and in 2010, with the institution of the National Politics of Solid Residues (Law no 12.305), national standards were established aiming for the efficient treatment of the residues. Therewith there grew the stations of treatment of effluent ones in industries and even in condominiums, besides initiatives of collection and destination specifics for the solid waste. With drawing the exclusive responsibility of the public sector in looking for solutions for the environmental impacts resulting from the lack of basic sanitation, the legislation brought to the great residues producers – the condominiums, for example – the necessity of carrying out discards it of effluent ones in specific places, of reduced risk to the nature, and with least standards of prior treatment. However, many condominiums still use of archaic systems, like the septic tank, where the residues are deposited in a well which liquid content finishes absorbed by the ground, when the solid debris is withdrawn mechanically only.

Besides the Federal Government, states and local authorities look, more and more, to introduce laws that establish alternatives viable and appropriate to the respective reality of social and economic development. In the Parana, for example, there was extinguished the practice of the "eternal" environmental licenses, subjecting the properties to the periodic works of inspection of the activities regarding the treatment of the residues there produced.

In this context, the main objective of the study was to analyze the implementation of an up flow digester in a residential condominium in Foz do Iguaçu, Parana, showing the feasibility of implementing such a digester to reduce environmental impacts caused by the disposal of such waste and the use of biogas generated from the anaerobic reaction of the material in the generation of thermal and electric energy, with reduced emission of greenhouse gases.

2. Theoretical Review

The anaerobic fermentation processes that produce methane, have always been used by man for the treatment of sewage (septic tanks), which served both to treat domestic sewage from small communities, as the waste of food industry or agriculture. With the passage of time, these simplified treatment systems have evolved and passed the so-called digesters in use, to effect stabilization of the resulting sludge from the primary sedimentation and aerobic biological treatment of sewage (ANDREOLI et al.,2001).

The models of biodigester in use at present have his specificity according to the finality to which the project serve, be for production of biofertilizer, for treatment of effluents or solid residues, or even for energy production.

The Up flow Anaerobic Sludge Blanket (UASB), also known as anaerobic reactor of sludge blanket, is the model generally used for very high biomass concentration. So, the applied volume is quite reduced if compared with other systems of treatment of sewer pipe.

The up flow anaerobic reactor, basically consists of a tank having in the bottom one digestion system and in the top part a settler preceded by a system for the separation of gas, as shown schematically in figure 1. The liquid residue being treated is evenly distributed in the reactor from the bottom and goes through a biological layer of mud, which turns organic material into biogas (NOGUEIRA, 1986).

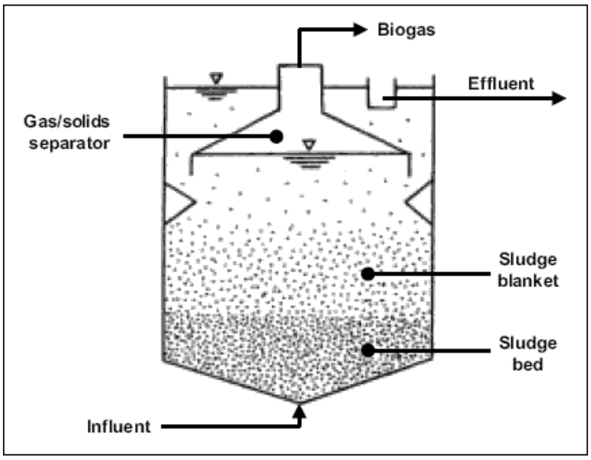

Fig. l: Scheme of a UASB model biodigester.

The structure of UASB is organized in order to make possible the separation and the accumulation of the gas, resulted from the separation and from the return of the biomass, preventing therefore the gas with the effluent. The gas used for the production of energy is collected in the superior part of the reactor, which conical or pyramidal structure allows the sedimentation of the solids there even, dripping for the walls and culminating in the body of the reactor (VON SPERLING, 1996). The separation liquid-solid, so, is not damaged, as soon as the gas bubbles do not penetrate in the sedimentation zone.

As result, the concentration of biomass in the reactor remains elevated and the effluent goes out clarified. The sludge produced out stabilized, in reduced quantity, being able to be dehydrated subsequently in drying beds.

Several sewage treatment plants and organic waste digester use RAFA model, resulting in a compact treatment system and easy operation. When the low cost allied to this easiness, it makes this model the most appropriate thing to residential condominiums, dispensing, inclusive, the necessity of skilled labor.

The energy production is based on two different residues: the residential sewer pipe (residual waters) and the garbage. In the first case, the production is based on the volume of the unloading of a toilet. The residual waters are composed of approximately 99,9% of water, when there is the remainder (0,1%) a mixture of organic, inorganic solids and micro-organisms (JORDÃO; PESSÔA, 1995).

In the system based on residential garbage, the organic residues formed by remains of plants, barks of fruits and greens, foods in decomposition, are separated of the inorganic residues (paper, plastic etc.) from the implementation of selective collection of the garbage. One of the measures of introduction of this system is in the awareness of the residents and his promise of separating the produced residues.

3. Methodology

(A) ESTIMATE OF THE QUANTITY OF PRODUCED BIOGAS

The estimate of the amount of sewage available for treatment in the digester was carried from the selection of the condominium monitored to verify the digester implementation feasibility.

The residential assessed is located in the city of Foz do Iguaçu, western Parana. The building consists of 20 floors with 8 apartments per floor, a total of 160 apartments.

At the time of the study (September/2015), a survey conducted by the building's management has identified a total of In total, the condominium has 720 inhabitants. For this population, the average sewage generated daily per apartment was of 0,64 m^3 in order. To determine the amount of biogas from the sewage, the conversion factor proposed by COELHO et al (2006) was used, which equals 0.07361m^3 of biogas each m^3 of wastewater treated.

Total production of biogas for this residential condominium was estimated by taking the values of organic waste and sewage.

To estimate the amount of sewage produced by households was used benchmark adopted by water utilities and Brazil's sewage, consisting of a daily total of 0,18m^3 sewage produced per capita.

Apart from the sewage residue, they were considered in the study the food scraps and organic waste generated by the residents. According to BRAZILIAN YEAR BOOK OF THE INDUSTRIES OF BIOMASS AND RENEWABLE ENERGIES 2012/2013, for the production of 1 m 3 of biogas it is necessary to consume nearly 13,23kg of organic garbage. On average, an adult person produces equivalent to 600 g of garbage in a day, corresponding, in a city with 20 thousand inhabitants, to the production of nearly 12 thousand kg/day (MARA, 2003). In cities of small transport, it is appreciated that the quantity of home garbage produced by inhabitant is between 400 and 600g daily rates and that in the great centers this quantity can bring near to 1,5kg/inhabitant/day (ALVES; LUCON, 2001).

(B) SINZING THE BIODIGESTER

The dimensions of the digester (equation 1) was based on calculations of CHERNICHARO (2007):

$$V = Q * HRT \tag{1}$$

where HRT is the hydraulic retention time of the biomass in the digester.

The total volume of the biodigester of rising flow is determined from the volume calculated by the equation 1, added up one to the volume of biogas produced from the employed biomass. The area of each module and the width of the reactor and of the module of the biogas are obtained by the equations 2 to 4, respectively.

$$A_u = \frac{V_u}{H} \tag{2}$$

$$L_1 = \sqrt{A_{reactor}} \tag{3}$$

$$L_2 = \frac{A_{biogas}}{L_1} \tag{4}$$

From the dimensions of the reactor, it is possible to define the volumetric hydraulic load (VHC) of the biodigester (equation 5).

$$VHC = \frac{Q}{V} \tag{5}$$

4. Results and Discussion

With the data referring to the generation of sewer pipe and arrangement of organic residues of the residential condominium, as well as the daily necessity of biogas for the generation of energy, presented in the Table 1, determining the volume of digester required for biogas generation was determined.

Table 1: Data generation and biogas consumption.

	Residential Data	**Productio of biogas (m^3/day)**
Residents	720	
Sewer	129,6 m^3	9,53
Organic waste	76,93 kg	5,81
Consumption of gas	0,33 m^3/d/people	237,6
m^3 of biogas	0,40 kg of GLP	-

Like presented in the Table 1, the production values of biogas for consumption it is of around 15,34 m^3/day, with a middle total consumption of around 238 m^3/day in the residential.

The quantity of the biogas produced in the process of digestion of the sewer pipe is small regarding the daily necessity applied for energetic use of the inhabitants of the analyzed condominium. However, the implementation of the biodigester, besides complementing the generation of energy, still secures his production from a source of renewable energy and not pollutant.

The use of biogas generated by the anaerobic digestion process of sewage and organic wastes generated by the residential, will contribute directly to the treatment of waste prior to disposal, and the gas may be used to generate thermal energy, for example.

Although a small biogas production, compared to consumption, the economy generated by production, according to the current values of natural gas and using the conversion shown in Table 1 for the 1 m^3 of biogas compared to GLP gas, it is of U$230,00 in a month on average, totalizing a value of U$2800,00n a year.

Based on the daily production of biogas generated from waste by residents of the condominium, the dimensions of the digester were calculated from the equations 1 to 4, with the results shown in Table 2.

Table 2: UASB digester size for generating biogas from sewage and domestic organic waste.

$A_{reactor}$ (m^2)	26,6
A_{biogas} (m^2)	3,8
L_1 (m)	5,2
L_2 (m)	0,8
V (m^3)	118
VHC (m^3/day)	1,3

Apart from energy production, the installation of the digester will bring the benefit of stabilization of sewage generated, guaranteed to minimize the pollutant load of wastewater. This treatment, together with the environmental advantages, ensures not generating fines for irregular disposal of sewage generated, which can vary according to the country. In Paraná, for example, the fine for improper disposal of sewage could reach U$ 21000,00

5. Conclusion

The project of introduction of the biodigester is theoretically viable, since the equipments and materials required for system assembly are available in the market and the technology involved in the UASB digester is comparatively simple and of low cost, besides single operationally.

The project of auto-generation of electric and thermal energy from the biogas originating from sewer in a residential brings environmental benefits, like the reduction of the release of greenhouse gases into the atmosphere and reduction of the launch of sewer in the nature.

The uses of biogas generates savings in property, since it is possible to replace conventional systems for the use of gas to generate heat and electricity, the latter in accordance with the current legislation of the place power company.

The digesters are excellent ways of independent treatments of residues and sewer and they can be expanded even for communities without basic sanitation.

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