BIOGAS PRODUCTION BY ANAEROBIC DEGRADATION OF SUGAR CANE VINASSE: INVESTIGATION OF THE HYDRAULIC AND ORGANIC RATES APPLIED TO UASB REACTOR FOR PROCESS OPTIMIZATION

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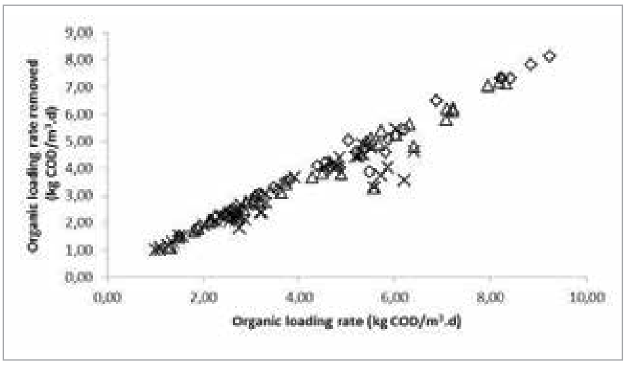

Figure 1. Organic loading rate removed in R1 (X), R2 (Δ) and R3 (◊) as a function of organic loading rate applies to the reactors

In an alcohol distillery, 40% of the chemical energy contained in the cane sugar is recovered as alcohol while 31% remains in the bagasse (26%) and vinasse (5%). Sugar cane mills uses bagasse extensively to meet the demand for energy in the production process; however, the content of energy remaining in the vinasse, although significant in the energy balance, is still mostly unexploited as such. Usually, the primary use of vinasse is for fertigation in its raw state.

The anaerobic digestion of organic matter is a suitable option to exploit the vinasse energy potential without loss of the fertilization potential. This process generates biogas, a fuel with a high-energy content, composed primarily of methane, similar to natural gas and as such having the same uses.

Researchers have conducted studies aiming to degrade vinasse and generate biogas, using anaerobic reactors at various scales. However, reactor design imperfections and the natural difficulties of maintaining high rate anaerobic digestion for extended periods for such a difficult to degrade waste have prevented the widespread use of this technology to process vinasse. There are many steps to overcome before a high rate anaerobic compact and efficient reactor will reach the maximum potential of organic matter removal and biogas production. Furthermore, as large quantities of alkali are needed to maintain the proper pH for anaerobic digestion of vinasse, its balance optimization is an important research topic.

To overcome at least part of the difficulties, this project aims to investigate the hydraulic and organic loads applied to a pilot scale anaerobic reactor, to obtain rational criteria for reactor design and ensure optimum anaerobic degradation of vinasse, biogas production and minimization of alkali use.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Three pilot-scale upflow anaerobic sludge blanket (UASB) reactors were operated. Reactor 1 (R1) operated without recirculation, while reactors 2 (R2) and 3 (R3) operated with recirculation rates of 1:3 and 1:5, respectively. The hydraulic organic loading rate (OLR) gradually increased in steps in order to adapt the anaerobic sludge to the vinasse. The OLR applied to R1, R2 and R3 ranged from 1.0 to 6.4; 1.0 to 8.3 and 1.0 to 9.3 $kgCOD.m^{-3}.d^{-1}$, respectively.

The COD removal efficiencies over the applied OLR were (83±13)% for R1, (88±7)% for R2 and (90±7)% for R3. The results indicate that there is an almost perfect correlation between applied and removed OLR (r^2 higher than 0.95), as shown in *Figure* 1. The higher efficiencies shown by reactors R2 and R3 are attributed to the effect of recirculation, as this is the only operational parameter that differs from reactor to reactor in this experiment.

The biogas production from anaerobic degradation is directly proportional to the removed organic load. The highest productivity (2.25 $LCH_4\ L^{-1}d^{-1}$) was obtained from reactor R3 under 8.25 $kgCODm^{-3}d^{-1}$, generating 344 gCH_4d^{-1}. The methane potential for power generation is 1.686 kWh/$kgCH_4$, considering as 35% the overall energy conversion efficiency of gas generator sets (Van Haandel, 2005). Based on this result, the production of 1 m^3 of ethanol, that would result in 13 m^3 of vinasse as waste (40 gCODL), will yield 190 kWh of electric energy (*Figure 2*).

The distillery that supplied vinasse for this research produced 140,000 m^3 of alcohol during the 2014/2015 harvesting season. Using UASB reactors with the same methane productivity obtained in this research this plant could supply electric energy for 48,000 homes (157kwh / month), equivalent to approximately 216,000 inhabitants, in this period.

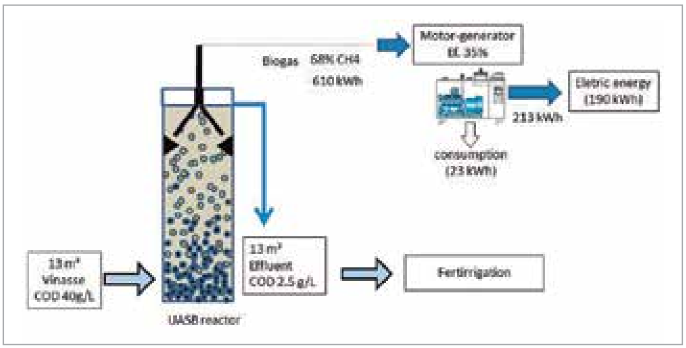

Figure 2. Flowsheet of electric energy generated by 13 m^3 of vinasse

MAIN PUBLICATIONS

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