# An integrated system for biogas generation and recovery of nutrients from food waste: a possible resources-oriented option for rural towns

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**Abstract**

The current paper presents the work currently being developed at an integrated platform for methane production and recovery of nutrients (ammonia and phosphorus) from food waste generated by restaurants on the campus of the Federal University of Minas Gerais (UFMG), Brazil. The platform was conceived as a research unit to test sanitation solutions for small rural towns. It has the capacity to treat 1 ton of food waste per day and consists of a sorting/grinding unit (where a small volume of water is added to the waste), an equalization tank, a thermophilic digester, an upflow anaerobic sludge blanket (UASB) reactor, sludge drying beds, a biogas collection system (connected to both the digester and the UASB reactor), biogas treatment columns and a biogas-powered electricity generator. The effluent from drying beds presents high ammonia concentrations (more than 1200 $mgNH_3$-N/l). Ammonia will soon be recovered from the effluent using a simplified chemical stripping unit, which should remove approximately 90% of the total ammonia. The remaining ammonia and organic matter will be removed in compact high-rate ponds. The biomass produced in the ponds will be composted and used as fertilizer. The treated effluent will be reused for crop irrigation. The platform has been in operation for 395 days, treating 340 Kg of food waste per day. pH, total and volatile solids, alkalinity, and biogas composition and production were monitored at the digester. The system showed a methane yield of 489 $m^3CH_4.tSV^{-1}$, an amount that is sufficient to meet the energy demand of the plant. The proposed system shows a feasible alternative for the generation of biogas and by-products from the treatment of food waste generated in small rural towns.

**Keywords**

food waste digestion, rural sanitation, anaerobic digestion, nutrient recovery

## INTRODUCTION

There has been increased demand for sustainable technologies for the treatment of Municipal Solid Waste (MSW) in Brazil, especially since the implementation of the new National Solid Waste Policy (PNRS, 2010). Of particular interest is the organic fraction of MSW, which accounts for approximately 51% of MSW (by weight) (FERREIRA, 2015), as it is suitable for biological treatment processes by anaerobic microorganisms, that can result in the production of methane gas ($CH_4$), which can be a valuable resource, especially in isolated rural towns. Treatment of the organic fraction of MSW in a methanisation system can be a viable alternative for small rural towns, as it allows: i) production of valuable biogas from organic waste; and ii) recovery of other valuable resources from the sludge and liquid effluent from the system, including ammonia fertilizer, compost and water for crop irrigation, which could be valuable resources in small rural towns with agricultural activities.

The current study proposes an integrated system for the treatment of organic waste, sludge by-products and biogas generation (FERREIRA, 2015). This system has been in operation since the end of 2013 at campus Pampulha of UFMG - Belo Horizonte / Minas Gerais / Brazil, and consists

of a: i) dual-stage methanisation system (digester + UASB); ii) energy recovery unit biogas; and iii) unity of post-treatment (gas stripping + high rate ponds) and recovery of by-products (sludge and liquid from the digester).

## MATERIAL AND METHODS

The methanization reactor was designed as a complete stirred tank reactor (CSTR), with a volume of 18.8 $m^3$, operated in single stage wet anaerobic digestion. The reactor was fed daily with about 500 kg of food waste and the parameters pH, temperature, redox potential, alkalinity (IA/PA), biogas composition and production, total and volatile solids were monitored.

The digester's effluent was monitored for total and volatile solids, chemical oxygen demand (COD), biochemical oxygen demand (BOD), nitrogen series, ortho-phosphates. All analyzes were performed according to the Standard Methods (APHA, 2012).

## RESULTS AND DISCUSSION

The system was monitored for 395 days and processed on average 337 kg of food waste per day. The reactor was operated with solids content of about 5%, hydraulic retention time (HRT) of 30 days, pH was 7.6 and organic loading rate (OLR) was, approximately, 1.0 $KgSV.m^3.d^{-1}$.

The monitoring of biogas production over the experiments obtained average values of. The average production biogas and methane were 10 19 $m^3d^{-1}$ and $m^3CH_4.d^{-1}$, respectively. The maximum yield of $CH_4$ observed was 489 $m^3CH_4.tSV^{-1}$. The preliminary characterization of some parameters of the methanization reactor effluent indicates $NH_4^+$ and COD concentrations of 1084 mg/L and 4367 mg/L, respectively.

## CONCLUSIONS

The methanization reactor has been producing energy to meet the energy demand of the plant. Furthermore, the proposed system will soon start producing other valuable resources such as ammonia fertilizer, organic compost and water for irrigation. Thus, the proposed system can be a promising alternative to solve an important sanitation problem (management of organic wastes) while producing energy (biogas) and other valuable by-products.

## REFERENCE

American Public Health Association. *Standard methods for the examination of water and wastewater***.** 22. ed. Washington Dc: American Public Health Association Publications, 2012.

FERREIRA, B. O. Avaliação de um sistema de metanização de resíduos alimentares com vistas ao aproveitamento energético do biogás. Escola de Engenharia, UFMG, Belo Horizonte, 2015. 124 p.