CO-DIGESTION OF MIXED SEWAGE SLUDGE AND FRUIT AND VEGETABLE WASTES. EFFECT OF DIFFERENT MIXTURES ON BIOGAS YIELD.

B. Arhoun, C. Gómez Lahoz, J.M. Rodriguez-Maroto, F. Garcia-Herruzo*, and C. Vereda-Alonso.

Chemical Engineering Department. Faculty of Sciences. University of Malaga. 29071-Malaga-Spain. (herruzo@uma.es)

ABSTRACT

A lab-scale experiment for the anaerobic co-digestion of FVW and municipal mixed sludge under mesophilic condition is investigated. Initially the digester was fed with mixed sludge (MS) from wastewater treatment plants with an average organic loading rate (OLR) of 0.63 (g $L^{-1}d^{-1}$). The co-digestion of mixed sludge and FVW was performed at various % FVW in the mixture (v/v), increasing organic loading ratios (OLRs), from 0.63 to 5.5 (g $L^{-1}d^{-1}$). The experimental specific biogas and methane production are 0.656 L $g^{-1}$and 0.340 L g^{-1} respectively. Alkalinity and pH remains relatively constant regardless the introduction of different proportions of FVW in the mixture. Co-digestion, compared with the digestion of MS as single substrate, improves the biogas and methane production.

I. INTRODUCTION

Fruits and vegetables are widely produced and consumed around the world. During the transportation of fruits and vegetables from the production site to the wholesale market, a huge percentage of damage is inevitable, mainly due to improper conditions of conservation and deterioration of fruits and vegetables. Wholesale market generates a considerable quantity of fruits and vegetables wastes ~~and~~ that can be largely and easily collected. As a consequence of the important quantity of these wastes, ~~that requires~~ a sound management is required to reduce the associated environmental problems. Most of these wastes ~~were~~ are usually deposited in a landfill site. The transport of FVW from the wholesale to the landfill site ~~is~~ poses a considerable logistical and financial cost ~~and~~ besides the additional~~ly~~ environmental problems ~~for deposition of these wastes facilities~~.

These wastes contain large quantities of biodegradable organic fractions with high moisture that facilitates their biological treatment. One of the best alternatives to landfill disposal of large quantities of this residue is the anaerobic digestion (AD) (Bouallagui et al., 2005).

Given the very large biodegradable organic content of FVW, a major limitation ~~of~~ for the anaerobic digestion of these wastes is the rapid and large production of volatile fatty acids (VFA), ~~resulted~~ that may result in a ~~serious~~n important acidification ~~in~~ of the anaerobic digester, ~~consequently~~ that ultimately could inhibit~~s~~ the activity of methanogenic bacteria (Bouallagui et al., 2005). These limitations can be overcome ~~basically~~ by co-digestion with others substrates

When considering the possible management solutions for this kind of wastes it should be taken into account that FVW are generated all around the year in wholesale markets. Co-digestion with other residues which are produced also throughout the year could be an interesting way to overcome these difficulties (Arhoun et al., 2013). ~~Introduction~~ Management of FVW as highly biodegradable residues in municipal wastewater treatment plants (WWTP) ~~and~~ can be achieved by co-digestion with mixed sewage sludge. In principle, this codigestion will increase~~s~~ the OLR and therefore could enhance biogas production and plant economy~~ic~~ (Fonoll et al., 2015).

The aim of this investigation was to compare anaerobic digestion of mixed sewage sludge with co-digestion of this sludge with Fruits and vegetables wastes.

II. EXPERIMENTAL

Feedstock and sludge:

Raw FVW were obtained from rejections from a fruit and vegetable wholesale in Malaga, Spain, which mainly contained residues of vegetables such as zucchini, onion, tomato, lettuce, and different fruits, such as peach, apple, melon, pear, orange and watermelon, etc. These wastes were initially minced into smaller pieces before being mashed with beater for 5 minutes in order to achieve a correct size reduction The homogenized substrates were stored in a -20 ºC freezer ~~for~~ until used for digestion. Inoculum and mixed sewage sludge were collected from the MWTP (Malaga, Spain). The characteristics of Inoculum, mixed sewage sludge and FVW are given in the results section, table 1.

Reactor design and operational conditions

In order to make a comparison on the digestion performance~~s~~ between the lab-scale and WWTP digester, ~~the~~ similar operation conditions w~~a~~ere~~s~~ employed for digestion in the lab-scale system including temperature, flow rate Q (m^3d^{-1}) and agitation.

All experiments were carried out in a digester (BIOSTAT® E) which has a total capacity of 6.4 L and a working volume of 5 L. It worked as a stirred reactor with a continuous agitation of 100 rpm, and the temperature was maintained at 35 ± 1 ºC. Besides, the digester is equipped with two electrodes to measure the pH and redox potential values.

The reactor loading followed a withdrawal/feed method that basically consists on the removal of the same volume of sludge from the reactor as volume of substrate is fed immediately afterwards. A valve was used for the removal, and the feed was supplied using a 100 mL syringe.

All the experiments were performed in the sequential mode with daily feeding, six MS:FVW ratios (based on (v/v) ;100:0, 80:20, 60:40, 40:60???, 20:80, and 0:100) were applied. ~~As before, e~~Each experiment was repeated for 10 days???~~.~~

Analytical methods

The total solids (TS), volatile solids (VS) and total chemical oxygen demand (COD) were measured according to standard methods (APHA et al., 1999). The rate of biogas production was measured by a volume displacement method and its composition was determined by gas chromatography (Perkin-Elmer Autosystem) with thermal conductivity detector, and a Supelco column (15 ft x 1/8''; 60/80 carboxen 1000). The oven, injector, and detector temperatures were 180, 180 and 220 ºC, respectively. Helium was used as carrier gas at a flow rate of 30 mL/min. The elemental analysis (C, H, N, O) of the TS, of Inoculum, mixed sewage sludge and FVW, was performed using a Perkin Elmer CHNSO 2400 apparatus.

III. RESULTS AND DISCUSSION

Feedstock and Sludge characteristics

The main characteristics of the inoculum, mixed sludge (MS) and fruits and vegetables wastes (FVW) used in our experiments are listed in table 1. The C, H, O content in the FVW was higher than for the MS whereas the N content was much lower, so there are large differences in the C:N ratios. Also the values of TS and VS obtained for FVW are higher than for MS. Finally, there are important differences with respect to the pH value.

Co-digestion of strawberry waste with pig manure

Fig. 1 shows the biogas, CH_4 production rates and OLR (volume of biogas or CH_4 produced each day per volume of sludge in the reactor) for the different MS:~~-~~FVW ratios explored. The reactor was initially fed with SM and subsequently fed with the mixtures of SM:FVW. The proportion of FVW in feedstock sequentially increased up to 100% while maintaining constant Q operated. As can be seen, as the ratio of FVW increases the biogas, CH_4

Con formato: Conservar con el siguiente

Comentario [CGL1]: No veo dónde se define Q

production rates and OLR increases (from 0.63 to 5.5 (g $L^{-1}d^{-1}$)). The experimental specific biogas and methane productions are 0.656 L $g^{-1}$and 0.340 L g^{-1} respectively. Alkalinity and pH remains relatively constant regardless the introduction of different proportions of FVW in the mixture.

Parameter	inoculum	Mixed sludge	FVW
pH	7.40	6.8	3.5
C (%)	28.96	41.39	42.31
H (%)	5.110	6.471	6.908
N (%)	4.749	5.707	1.736
O (%)	33.67	32.93	47.33
C/N	6.09	7.25	24.37
TS (%)	2.11 ± 0.06	1.64 ± 0.03	11.82 ± 0.18
VS (%)	1.50 ± 0.05	1.26 ± 0.04	10.92 ± 0.10
VS/TS	0.71	0.76	0.92

Table 1. Main characteristics of the materials used for digestion

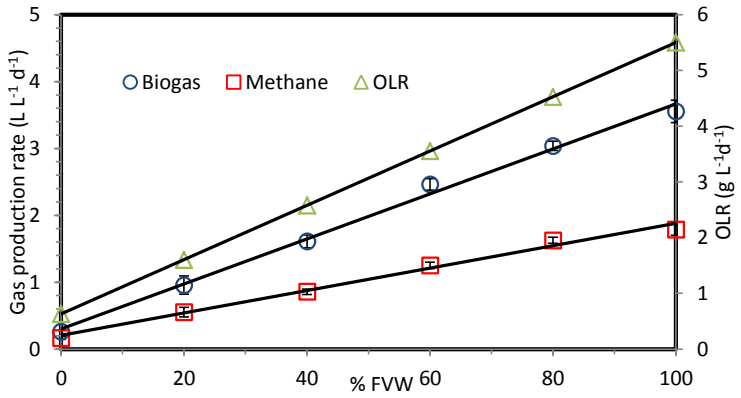

Figure 1. Biogas, CH_4 production rate and OLR versus % FVW in the mixture

IV. CONCLUSIONS

The synergistic behavior of mixed sewage sludge and FVW is clear. The co-digestion of both substrates results in the production of more biogas than the digestion of mixed sewage sludge used as single substrate. Furthermore, larger OLRs can be treated without problems with the stability of the digester.

V. ACKNOWLEDGEMENT

Comentario [B2]: Agradacimineto ??

Comentario [CGL3]: Como en el caso anterior, hay que consultar esto con Maroto y Paco.

VI. REFERENCES (Arial 10)

APHA, AWWA, WEF, 1999. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, Washington, DC.

Bouallagui, H., Touhami, Y., Cheikh, R.B., Hamdi, M., 2005. Bioreactor performance in anaerobic digestion of fruit and vegetable wastes. Process Biochem. 40, 989–995. doi:10.1016/j.procbio.2004.03.007

Arhoun, B., Bakkali, A., El Mail, R., Rodriguez-Maroto, J.M., Garcia-Herruzo, F., 2013. Biogas production from pear residues using sludge from a wastewater treatment plant digester. Influence of the feed delivery procedure. Bioresour. Technol. 127, 242–247. doi:10.1016/j.biortech.2012.09.075

Fnoll et al., 2015

Comentario [B4]:
Fnoll et al., 2015
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Anaerobic co-digestion of sewage sludge and fruit wastes: Evaluation of the transitory states when the co-substrate is changed