ANAEROBIC CO-DIGESTION OF MUNICIPAL SEWAGE SLUDGE AND FRUIT/VEGETABLE WASTE: EFFECT OF DIFFERENT MIXTURES ON DIGESTER STABILITY AND METHANE YIELD

B. ARHOUN, C. GOMEZ-LAHOZ, J.M. RODRIGUEZ-MAROTO, F. GARCIA-HERRUZO, C. VEREDA-ALONSO.

Chemical Engineering Dept. Faculty of Sciences. Campus de Teatinos. Universidad de Málaga. 29071-Málaga Spain.

There are different options for the management of fruit and vegetable wastes (FVWs), but the most environmental-friendly is the anaerobic digestion, because it allows an optimum recovery of materials and energy from the two by-products: biogas and digestate. Nevertheless, in many cases there are economic and technical problems that cause the selection of other alternatives. Frequently these wastes are produced in large quantities but only during few weeks of the year. In these cases, this is the most important economic problem, because large digesters that would be used only for short time periods every year would be required. In addition, a close control of the pH of the digester is required for this kind of residues, for which the hydrolysis is usually faster than the methanogenesis, so large concentrations of fatty acids should be prevented to maintain the adequate pH value for anaerobic digestion that should be neutral or slightly alkaline.

Both problems can be simultaneously overcome by the co-digestion with other residues that are produced throughout the year. Among the benefits of co-digestion, one of the most important is the improvement in the feedstock characteristics, since it may allow a more equilibrate composition resulting in a better performance of the digester in treatment capacity, and a better quality of biogas and digestate. The co-digestion with other substrates with a complementary composition that are produced throughout the year and that are already managed by anaerobic digestion is probably the optimum management option. For these cases, if the existing anaerobic digester is oversized and allows the introduction of additional volumes of wastes, the mean retention time of the digestate should be maintained.

Therefore, the anaerobic co-digestion of fruit and vegetable waste (FVW) and municipal sewage sludge (MSS) under mesophilic condition and a constant hydraulic retention time (20 d) is studied. The effects on digester performance of the FVW:MSS ratio and the organic loading rate (OLR) were examined. The OLR is the mass of volatile solids fed per volume of digestate and day.

The FVWs samples were obtained from the wholesale market of Malaga, where about 10 t are produced each day that can be easily separated from other municipal solid wastes. The MSS is obtained from the mixed sludge that is fed to the anaerobic digester in one of the waste water treatment plants of Malaga, treating wastewaters that are mainly from residential source. The mixed sludge is obtained from the primary and secondary settlers of the plant. These substrates present quite different characteristics; for instance the C:N ratio of FVWs is 25.4 while the same ratio for the MSS is 6.97, and the total solids are respectively 9.98 % and 2.53 %. The later difference is even more important in terms of volatile solids per volume of sludge (9.56 % and 2.06 %). Therefore, if the mean retention time of the sludge in the digester is kept constant, the amount of OLR fed to the reactor will increase as the ratio of FVW:MSS is increased.

Initially the digester was fed with MSS from wastewater treatment plants with an average OLR of 1.03 kg_{VS} $(m^3\ d)^{-1}$, which is consistent with the working volume of the lab-digester (5 L) and the retention time (20 d). The stability of the digester is followed for 10 consecutive days before changing the feed composition to a FVW:MSS volume ratio of 20:80. Again, these feed conditions are maintained for 10 days, and then changed to the next feed composition. The FVW:MSS ratios explored are 0:100 ; 20:80 ; 40:60 ; 60:40 ; 80:20 and 100:0. Of course, as the FVW:MSS ratio increases the OLR increases too, so the experiments are performed with increasing the OLRs, from 1.03 kg_{VS} $(m^3\ d)^{-1}$ to 4.78 kg_{VS} $(m^3\ d)^{-1}$.

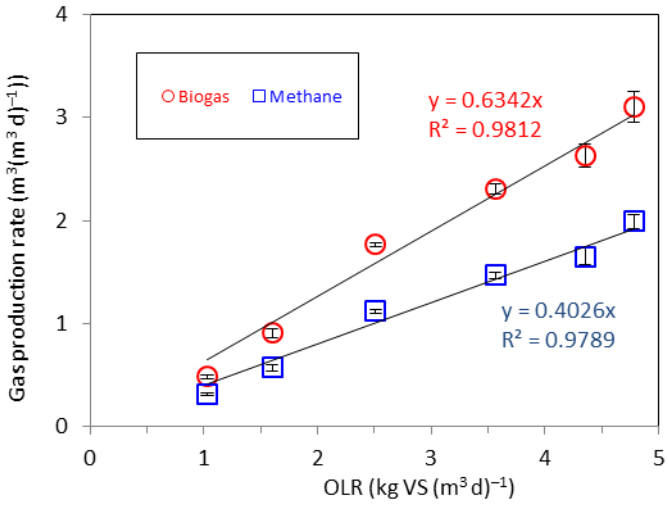

Figure 1. Biogas and methane production rate versus OLR

The biogas and methane production rates, for each FVW:MSS ratio explored, are presented in the figure. The experimental specific methane production was 0.303 m^3 $kg^{-1,VS}$ for MSS and 0.403 m^3 $kg^{-1,VS}$ for FVW as single substrate. This value varied for codigestion with a maximum of 0.445 m^3 $kg^{-1,VS}$ for a FVW:MSS ratio of 40:60. The average methane (CH_4) content in the biogas was about 62-64 %.

One of the targets of this study is to obtain the changes in the sludge characteristics in terms of total, partial, and intermediate alkalinities, and in the alkalinity ratio. These changes can be used as early warnings of possible problems related with the acid generation during the hydrolysis. As can be seen in Fig. 2, the alkalinity remains relatively constant regardless the introduction of different FVW:MSS ratios fed.

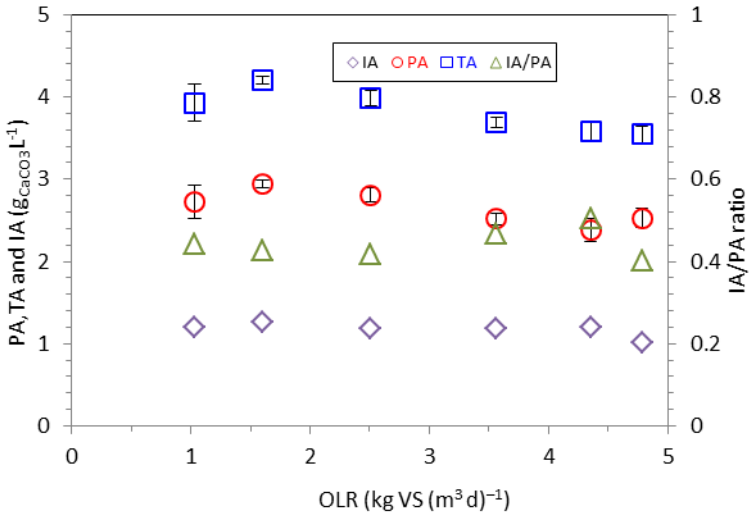

Figure 2. Alkalinity parameters for the sludge in the digester for the different experimental conditions. Intermediate alkalinity (IA), Partial Alkalinity (PA), Total Alkalinity (TA) and alkalinity ratio (IA/PA).