ONION WASTE TREATMENT PRELIMINARY ANAEROBIC RESEARCH DATA

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ABSTRACT: This work is focused to find a viable alternative for a sustainable onion residues treatment and recycling, by anaerobic digestion with biogas generation and bio-fertilizers reuse. Onion residues were treated by anaerobic digestion using as seed inoculum anaerobic sludge from treatment of wastewater barley malting process. Preliminary results at mesophylic temperature range, based on the exploratory results were: a) the biogas yield and anaerobic biodegradability of onion wastes were low, with potential higher delay bulbs than peels, due to acidification, b) two stages anaerobic digestion system should be tested, c) co-digestion should be tried, due to the high onion wastes C/N, d) lime pretreatment of onion wastes could improve alkalinity supply, e) type and amount of buffering agents need to be considered in the anaerobic digestion treatment of this wastes, because concerns about anaerobic bio-solid recycling to soil as organic fertilizer (salt effects on crops and water), f) disease fungal control must be verified with bio-solid obtained from anaerobic treatment of onion wastes.

Keywords: anaerobic digestion, biogas, bio-solids.

INTRODUCTION

The Colorado River Valley (Provincia Buenos Aires) is one of the main onion (Allium cepa L.) producing area of Argentina (15,000 ha). Last season almost 200000 tons of about a total production of 450000 tons were exported from this area. 90% of exported onion came from H. Ascasubi region. As far as infrastructure is concerned, in 2011 were 77 packing plants (sorting and packing). Onion packing plants, produces large volumes of waste, composed of peels, stems, roots, bulbs scales and out of spec discards (bulbs). These residues were estimated 3 to 5% of the total exported onion (12,000 to 20,000 tons). Out of spec are mainly due to fungal problems, main constraint to onion production and marketing. To maintain the productivity of the area and consolidate position at international markets, disease control is an essential task. Because most frequent final wastes disposal is soil amendment, treatment of onion residues should inactivate disease in order to maintain a sustainable production at this area.

Anaerobic digestion is a biological transformation process for treatment of organic waste (vegetal / animal), recovering bio-energy such as biogas, a mixture of methane and carbon dioxide. Anaerobic digestion has several advantage: energy recovery, disease control and higher quality of bio-solids for soil amendment. The biogas can be used as fuel for power generation or simply as heat source. The residual material after anaerobic digestion (stabilized bio-solids), can be used as organic fertilizer and / or soil amendment. Food waste, like onion wastes contain high soluble organics, they are converted to volatile fatty acids (VFA) at an early stage of digestion. A drastic pH drop will inhibit the initiation of methane fermentation with no sufficient buffering capacity (Kang & Jewell, 1990). In order to promote methane production, two phase concept were proposed (Ghosh, 1990).

Energy recovery from organic waste through anaerobic digestion occurs by conversion to methane of a significant fraction of the waste, which begins with hydrolysis of organic compounds and volatile fatty acids (VFA) production as initial step, to finally generate...
methane from such VFA (second step of the process). Vegetable residue from any type of agribusiness (shells and discards of any kind, potatoes, onions, tomatoes, etc.) can be processed by anaerobic digestion. Vegetable solid wastes represent a potential energy resource if they can be properly and biologically converted to methane (Gunaseelan, 2004, Cho et al 1995). Preliminary research have involved onion wastes anaerobic digestion test, in order to continue to future developing of pilot plant and industrial scale at packing onion plant of this region. Reactor design anaerobic digesters will be developed according previous experience of the research group (Campaña et al., 2008).

MATERIALS AND METHODS

Feedstock
Two types of onion wastes were tested, peels and discarded bulbs. Discarded bulbs was a very low pH (4.36), and 88.3 % Organic Matter (OM), similar to vegetable and fruits wastes (Bouallagui H., et al, 2004), liquor preparation included initial neutralization of acids (sodium bicarbonate). Table 1 shows waste onion characteristics. Onion peels with a very high DM (less than 1.5 % water) and 84.6 % OM, did not modify initial pH of liquor.

Seed Inoculum
Inoculum seed was obtained from an anaerobic pilot plant (psychrophyllic batch reactor-15 °C), RTAD, operating at a barley malting process near Bahia Blanca, that anaerobically treats excess activated sludges from wastewater treatment. Anaerobic stabilized malting sludge was a pH of 8.42, Solid Matter 3.57 %, 70.73 % of OM, and 50.76 gN /kg SM. See Table 2

Methods
Physicochemical measurements were carried out according to standard methods for analysis of water and wastewater (APHA, AWWA, WPCF, 1992). Assay bottles (Erlenmeyers 2000 ml) were weekly checked for gas generated. Biogas production was determined by the volume displacement technique.

Experimental Studies
Onion residues as substrate were treated by anaerobic digestion using as seed inoculum anaerobic sludge from treatment of wastewater barley malting process, with high concentration of microorganism, micro and macronutrients with high buffering capacity (alkalinity), essential to prevent acidification processes (Campaña et al., 2006). Lab trial tests used similar reactors to previous work (Campaña et al 2009) with an effective volume of 2000 ml and tested at controlled temperature (22 - 23°C), with duplicated samples. Lab reactors were charged with 50 % volume of inoculum seed (anaerobic stabilized malting sludge) and 50 % volume water with 30 g of onion wastes (peels or discarded bulbs). Hydraulic retention time was over 5 months, because microbial ecosystem adaptation to the new substrate (Raynal et al., 1998).

RESULTS AND DISCUSSION
In the figures 1 and 2, shows ph evolution and the biogas volume, obtained for both substrates tested. (R5: onion peels, R6: onion bulbs)

At figure 1, ph found during first stage, both substrates, 5.5 – 6.2, agreed with liquefaction (hydrolysis step) (Raynal et al 1998). Like other research studies published, an inhibition of hydrolysis was observed (Bouallagui et al, 2004), mainly for onion bulbs.

Tested Onion peels exhibited biogas yields similar to cellulose 0.32 l/g VS (Cho et al, 1995, Gunaseelan, 2004), and showed a different starting point of methane production.
Onion bulbs did not produce at least twice time in comparison with peels (Figure 2). C/N was too high (corresponding to onion wastes relationship), with low buffering capacity, (low nitrogen concentrations) (Romano et al., 2008). Co-digestion of onion waste and animal waste (pig, cow, hen manures) shall be tested (Bond et al., 2012). Different performance of biogas production and pH evolution between peels and bulbs onion wastes, confirm that bulb juices contain high concentrations of soluble organics, rapidly converted to volatile fatty acids, and thereby promoted, an inhibiting environment for methanogenic bacteria (Romano et al., 2007). The high I/F (Inoculum to Feed) relationship 0.5 was not enough to control inhibition of methane production (Cho et al., 1995). Alkaline pretreatment with and without co-digestion shall be tested too next (Carrerea et al., 2010).

CONCLUSIONS

The following preliminary conclusions may be resumed, based on the exploratory results: a) the biogas yield and anaerobic biodegradability of onion wastes were low, with potential higher delay bulbs than peels, due to acidification, b) two stages anaerobic digestion system should be tested, c) co-digestion should be tried, due to the high onion wastes C/N, d) lime pretreatment of onion wastes could improve alkalinity supply, e) type and amount of buffering agents need to be considered in the anaerobic digestion treatment of this wastes, because concerns about anaerobic bio-solid recycling to soil as organic fertilizer (salt effects on crops and water), f) disease fungal control must be verified with bio-solid generated from anaerobic treatment of onion wastes.

REFERENCES


### Table 1 – Onion wastes characterization

<table>
<thead>
<tr>
<th>pH</th>
<th>EC (DS/M⁻¹)</th>
<th>Walter (%)</th>
<th>Proteins (%)</th>
<th>Lipids (%)</th>
<th>Carbohydrates (%)</th>
<th>OM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,36</td>
<td>5,05</td>
<td>80</td>
<td>0,5 - 1,6</td>
<td>0,1 - 0,6</td>
<td>6 - 11</td>
<td>83</td>
</tr>
</tbody>
</table>

### Table 2 – Inoculum characterization

<table>
<thead>
<tr>
<th>pH</th>
<th>EC (DS/M⁻¹)</th>
<th>Solid matter (%)</th>
<th>Organic matter (%)</th>
<th>Organic C (%)</th>
<th>TNK (g/kg)</th>
<th>Ashes (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8,42</td>
<td>27,50</td>
<td>3,57</td>
<td>70,73</td>
<td>41,02</td>
<td>50,76</td>
<td>29,27</td>
</tr>
</tbody>
</table>

### Figure 1 – Average pH trend during test period.

![Figure 1 - Average pH trend during test period.](image1)

### Figure 2 – Biogas volume obtained period tested.

![Figure 2 - Biogas volume obtained period tested.](image2)