Biorefinery pilot plant for resources recovery from agricultural waste

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The agricultural wastes represent nowadays a consistent amount of the waste generated in EU, achieving at least the 50% of the fresh harvested crops and then a huge amount of biomass resources (www.biomassfuture.eu). In this scenario, the Circular Economy and the Bio-economy concept intersect in their common aims to add value to biological waste and residues (European Commission, 2018) by innovative holistic approach toward eco-efficient conversion routes and smart agro-waste management strategies which do not lead to disadvantageous consequences on soils, water and air quality (Fischer et al., 2011). During the last decays, the conversion of methane to energy (thermal and/or electrical) was the typical resource recovered through the anaerobic digestion of agricultural waste (Kleerebezem R. et al., 2015). However, the legal obligations included in the Circular Economy packages have the objective to increase the availability of secondary materials (feed materials, biowaste) for further exploitation through conventional technologies (e.g. composting and anaerobic digestion), (www.ec.europa.eu, 2018). In this context, the European project No Agricultural Waste (NoAW, H2020) has as its own goal to contribute to the advent of 'near zero-waste society' and to promote a circular economy (http://noaw2020.eu). As partner in the NoAW project, InnovEn SRL is performing the experimental activity on a biorefinery pilot plant close to a full-scale existing biogas plant located in Isola della Scala (Northern Italy, Veneto region), Figure 1. The objective of the project is the valorization of agricultural waste through their conversion into high value bioproducts, like polyhydroxyalkanoates (PHAs), Biogas and Digestate, Figure 2-black lines.

Figure 1, the global view of the operative Pilot plant, Società Agricola La Torre, Verona.

Table 1 Feedstock percentage composition and TS/TVS characteristics.

Feedstock composition	(%)	TS (kg/t)	TVS (kg/t)
Liquid Manure	50-77	90.4-95.5	73.2-75.5
Water	34-7	-	-
Maize Silage/Grass Residues	16	450-470	434-399

The raw material (1 m^3/d of the mixture reported in the table 1) is grinded through a pump and feed to the second unit, the 4 m^3 mesophilic anaerobic fermenter in order to produce volatile fatty acids (VFAs) which are the precursor for the biosynthesis of PHAs using selected mixed microbial culture (MMC). Then, the same volume is discharged and processed by the screw-press separator. The solid fraction fed the anaerobic digester (1 m3 of working volume), which operate at mesophilic conditions (37°C) and HRT of 14-20 days. Around 800 liters of liquid fraction rich of VFAs is processed through a screening unit with the objective to remove the course solids not removed by the screw-press. Then, the fermentation liquid is automatically fed to the Sequencing Batch Reactors (SBRs), aiming the selection of MMC and PHA accumulation respectively. The Selection SBR operates a feast/famine conditions with an HRT=SRT=2d and an vOLR of 3 kgCOD/m^3d. The selected biomass increase the PHA content in cells in the accumulation SBR, which are then extracted through the addition of sodium hypochlorite and sodium peroxide.

In the following table is reported the description of the total solids per each unit:

Table 2, Total solids and total volatile solids of the pilot plant referred to each unit of the process.

List of Unit	TS (kg/m3)	TVS (kg/m3)	MLSS (g/L)	MVLSS (g/L)
Storage of raw materials	75-110	60-65	-	-
Fermentation unit	68-73	54-58	-	-
Fermented solid fraction	250-300	225-253	-	-
Screw-press (Liquid fraction)	43-48	34-43	-	-
Anaerobic Digestate	150-160	120-140	-	-
SBR1	-	-	1.5-2.0	0.7-0.8
SBR2	-	-	1.5-2.0	0.7-0.8

The maximal capacity of PHAs production during the steady state is 0.72 kg/d and around 3 m^3/d of biogas and 50 liters of anaerobic digestate.
Currently, the upgrading of the solid/liquid separation to achieve purified and recovered VFAs from the fermentation liquid is also under investigation. On the other hand, enhanced filtration&separation system through membrane (red line, figure 2), could be an innovative approach to recover nutrients (e., phosphorus in the form of struvite) from the fermentation liquid and/or the anaerobic digestate.

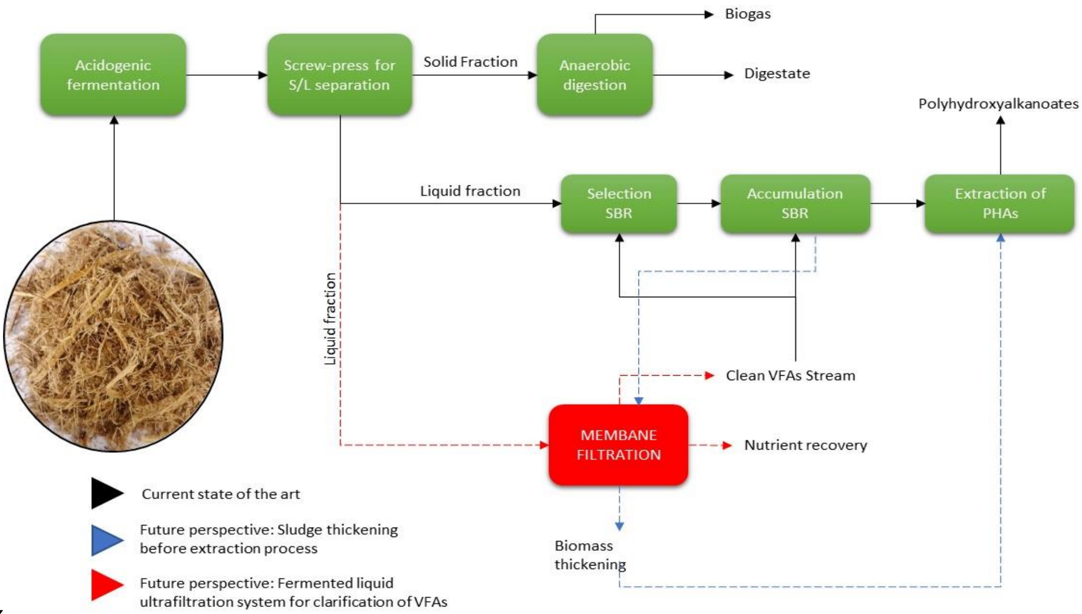

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Figure 2, novel biorefinery cascade by the utilization of membrane filtration to recovery macronutrients and to increase the end-process efficiency.

References

European Commission (October, 2018). A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment. Brussels: Research and Innovation.

Emans, A. (2016). Plastic Recyclers Strategy.

Kleerebezem R., J. B. (2015). Anaerobic Digestion without biogas (Vol. 14, 787-801). Environmental Science Biotechnology

Fischer M., (2011) Decoupling Natural Resource Use and Environmental Impacts drom Economic Growth Institute of Social Ecology Vienna, Alpen-Adria University, Austria

www.ec.europa.eu, 2018

https://ec.europa.eu/eurostat

ww.biomassfuture.eu

http://noaw2020.eu