A pilot-scale multi-purposes approach for volatile fatty acid, hydrogen and methane production from an automatic controlled two-phases anaerobic process for food waste valorisation

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Background

The sustainable growth is the main aspect of the ambitious plan adopted by the European Union (EU) 2030 strategy regarding the "Circular Economy" methods and their application [1]. This plan allows to take measures for the improvement of the life cycle of products, with benefits for environment, economy and society. Hence, in this context, the research lines need to adopt those approaches which foreseen a real conservative use of resources. Among others, carbon and nutrients recovery from organic wastes is still a pivotal concept. In particular, the organic waste produced within an urban scenario constitutes a valuable resource. A two-phases anaerobic process has been designed for food waste (FW) valorisation, after source sorted collection and screw-press as mechanical pre-treatment. The carbon source was treated in a pilot scale platform within the domestic wastewater treatment plant of Treviso (northeast Italy; Alto Trevigiano Servizi ATS S.r.l. **figure 1**).

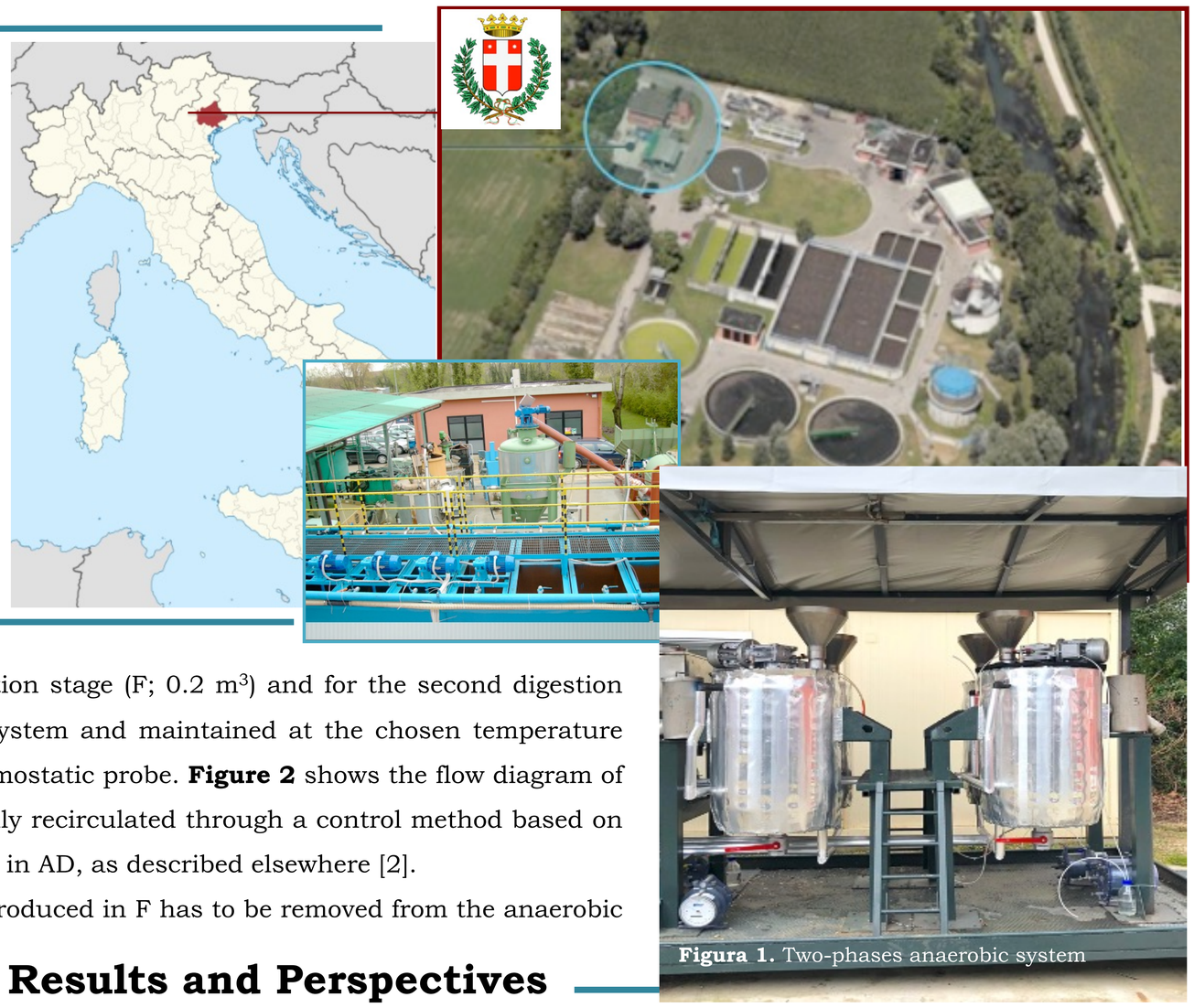

Figura 1. Two-phases anaerobic system

Process

Two pilot stainless steel CSTR reactors (AISI 304) were used for the first fermentation stage (F; 0.2 m^3) and for the second digestion stage (AD; 0.2 m^3). The three reactors were heated by a hot water recirculation system and maintained at the chosen temperature (37° C for F; 55° C for AD) using electrical heater controlled by a PT100-based thermostatic probe. **Figure 2** shows the flow diagram of the pilot scale anaerobic reactors system described above. The AD digestate was daily recirculated through a control method based on inputs from the online probes: the pH meter in F, pH meter and a conductivity probe in AD, as described elsewhere [2].

The basic idea of the process configuration is that a portion of VFA-rich mass flow produced in F has to be removed from the anaerobic system to be used for other purposes.

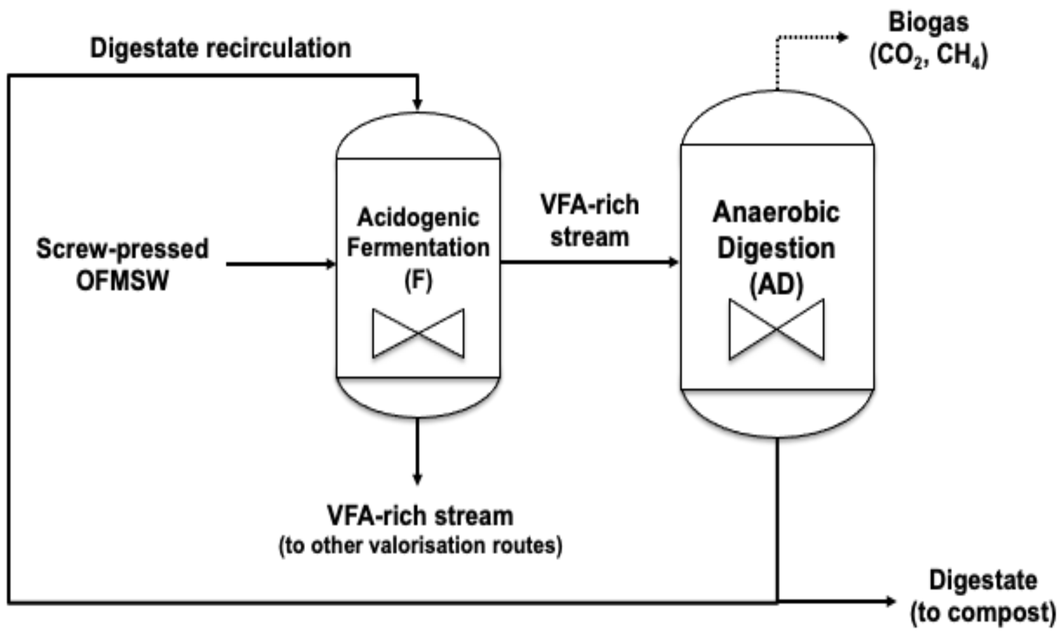

Figure 2. Two-phases anaerobic process configuration for biogas and VFA production

Results and Perspectives

The designed two-phases anaerobic process enhanced the VFA production to high concentration (24.4 ± 0.2 g COD_{VFA}/L), maximizing the acidification of the COD_{SOL} contained in the screw pressed OFMSW. The conduction of mesophilic FW fermentation at intermediate HRT (5 d) also led to a stable acidification activity, sustained by the digestate recirculation from the methanogenic reactor.

The thermophilic condition applied on the 2nd methanation stage increased the biogas recovery and the benefits from electricity generation without negative impact on the thermal balance of the process (as a whole). Besides biogas and compost, the availability of a VFA-rich stream with stable characteristics, especially the distribution of the short-chain molecules, gives the possibility to recover bio-products with high market potential. The removal of the 50% of the COD_{SOL} (in form of VFA) for parallel purposes (as made in this study) is not mandatory and it can be manageable, provided that the AD operating conditions are guaranteed. The amount of COD_{SOL} to be used for other scopes needs to be related to the market choice, which could be represented by VFA their self as building blocks for chemical industry, or by other VFA-derived bioproducts such as microbially synthetized biopolymers (such as PHA). This choice has to be also evaluated in terms of technical and economic feasibility in a realistic full-scale scenario.

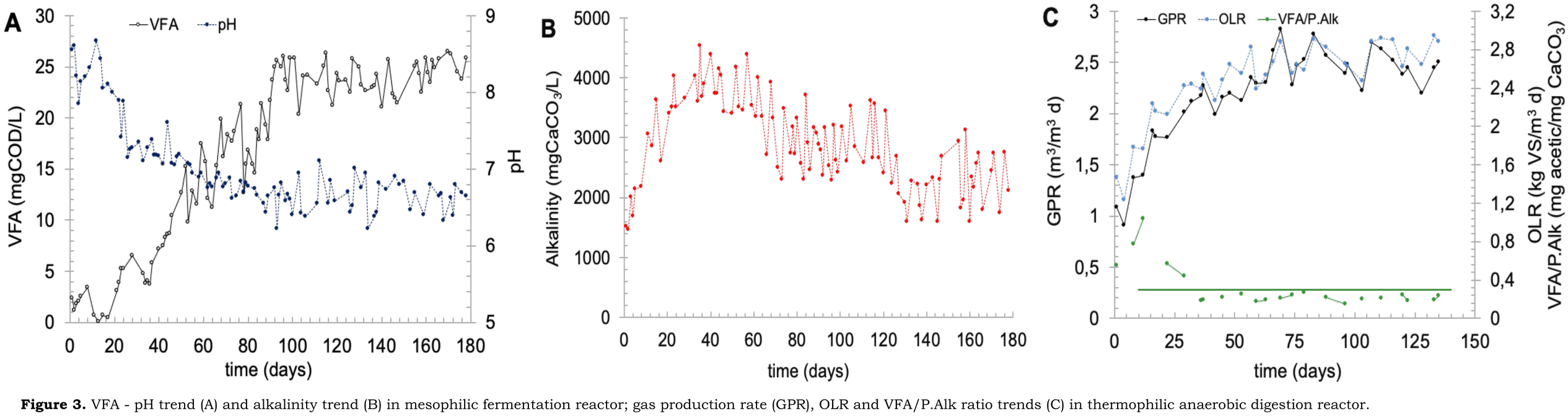

Figure 3. VFA - pH trend (A) and alkalinity trend (B) in mesophilic fermentation reactor; gas production rate (GPR), OLR and VFA/P.Alk ratio trends (C) in thermophilic anaerobic digestion reactor.

[1] ec.europa.eu; https://ec.europa.eu/clima/policies/strategies/2030_en.

[2] F. Micolucci, M. Gottardo, D. Bolzonella, P. Pavan, M. Majone, F. Valentino, Pilot-scale multi-purposes approach for volatile fatty acid production, hydrogen and methane from an automatic controlled anaerobic process, Journal of Cleaner Production 277 (2020) 124297. https://doi.org/10.1016/j.jclepro.2020.124297..