A circular economy system for multi-source biomass conversion to added value products: Life CircforBio

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The main aim of LIFE CIRCforBIO project was to achieve high GHG emission savings from the substitution of fossil fuels with advanced biofuels as well as to promote the realization of the circular economy concept for biomass. A multi feedstock biorefinery was designed and installed in TCLP. More specifically, the production of bioethanol, used oil (raw material for biodiesel) and other bioproducts from biomass resources was showcased under the concept of circular economy in Greece. The biomass streams under study were: food waste (households and restaurants), spent coffee grounds (cafeterias), bread waste (bakeries), agricultural residues (agricultural cooperatives), potato peel waste (potato chips industry), brewer's spent grains (breweries), orange peels and apple pomace (juice industry). At first, batch quantities of all biomass streams under study were supplied, through the supply and collection system set up for the feedstock supply needs.

The different substrates were first analyzed in terms of their composition and properties (e.g. moisture, pH, homogeneity, structural polysaccharides, oil, lignin, volatile matter) in order to determine their treatment requirements. Then a set of lab scale experiments in flasks was carried out. Samples were taken for analysis from all process stages in order to close mass balances for the whole system and to verify measurements. The aim of these lab experiments was to find the optimal conditions with the minimum resource consumption and then to test and adjust the optimal conditions to the pilot biorefinery plant. In particular, the objectives of the optimization of the biochemical process were to determine the optimal conditions for (i) the pretreatment of the biomass substrates (ii) the enzymatic hydrolysis of polysaccharides (starch, cellulose) (iii) the maximization of products yield (used oil, bioethanol, biogas) and (iv) the system's water and energy integration.

After the process conditions for each biomass stream were simulated and optimized at lab scale, the system operated at pilot scale at Lavrion Technological and Cultural Park (LTCP) for a sufficient period of time in order to optimize the processes in a larger scale. The process steps applied were: pretreatment (mechanical and/or physicochemical), enzymatic hydrolysis and fermentation, while the fermentation stillage and the thermal and the delignification pretreatment liquid effluents were anaerobically digested to produce biogas and digestate.

The quality of the ethanol produced was tested against the ethanol fuel standard EN 15376 and it was proved to be a high purity biofuel except for water content. The biofuel, also, had a distinct, however, mild odor. The quality of the produced digestate was also examined against the standards set in the national legislative framework (JMD 56366/4351, OG B 3339/2014) and the European policy framework (End-of-waste criteria for biodegradable waste subjected to biological treatment: compost & digestate, 2014). The quality of the produced used oil was tested against the standards regarding its use as raw material for the production of biodiesel. Given the low acidity content of the oil lipid sample, a direct transesterification process is likely to be feasible for the subsequent production of biodiesel. In addition, the moisture content is within the permissible range in order to avoid saponification phenomena and the low sulphur content is a high asset of this substrate in regards to biodiesel production.

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