Sustainable Wastewater Treatment Coupled to Energy Recovery with Microbial Electrochemical Technologies: The WE-MET Project

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Abstract

In recent years, sustainable treatment and utilization of wastewater are receiving considerable attention due to the growing shortage of freshwater resources, depletion of fossil fuel, and environmental pollution. Energy generation from "negative value" waste streams can simultaneously reduce the burden and costs associated with water and wastewater treatment, reduce pollution, and help meet the growing energy demand of modern society. On the other hand, in order to convert undefined and diluted waste organic substrates into clean (renewable and carbon dioxide neutral) fuels a platform of sustainable and selective catalytic routes needs to be developed and critically assessed under a range of conditions. To date, few technologies exist that enable coupling waste/wastewater treatment to energy or chemicals production. Among them, energy generation using Microbial Electrochemical Technologies (MET) seems to be very promising.

MET are innovative systems which combine municipal, domestic and industrial wastewater treatment to the generation of useful products such as electrical power (i.e., the Microbial Fuel Cell -MFC) or value-added fuels (i.e., the Microbial Electrochemical Cell -MEC). In this context, the overall aim of the WE-MET Project is to contribute boosting the transition of MET from laboratory-scale to practical "real-life" application. To accomplish this ambitious objective, WE-MET activities, are organized in 4, interconnected WorkPackages (WPs).

Specifically, WPs 1-3 will address some of the most pressing scientific and technological challenges of MET (e.g., reactor design and scalability; performance in "real" wastewaters, potential for nutrient removal / recovery) as well as the potential for integration of MET with other technologies (chemical catalysis; anaerobic digestion) to improve the overall process performance and maximize resource recovery. Finally, WP4 will scale-up the most promising technology and will assess its long-term viability through extensive pilot-scale testing and detailed Life Cycle Analysis (LCA). As for this latter aspect, LCA will also allow benchmarking MET against state-of-the art aerobic and anaerobic wastewater treatment technologies. Overall, the proposed approach, which combines both fundamental science and upscaling activities, will be crucial both to facilitate the development of technologies which are technically effective and sustainable and also to reach out end-users and stakeholders. This will be possible also with the help and support of an influential Advisory Board

composed of policy making institutions (e.g. European water supply sanitation technology platform), professionals (e.g., Tunisian WWT company and Agro-industrial company) as well as international representatives of scientific associations.

Among the goals and objectives of the WE_MET project the treatment and valorisation of solid wastes are included. Those are addressed by three different approaches. In the first approach anaerobic digestion (AD) of the primary municipal sludge is integrated with MET as shown in Figure 1. In this case the primary sludge is directly used for biogas production via AD and the digestate containing residual COD together with the biogas itself are further exploited for feeding the anode and the cathode of the MEC, respectively (Figure 1). In the second approach the insoluble substrates of raw wastewater are separated via primary sedimentation. The soluble organic matter is converted directly to energy via MET whereas the solids are catalytically convert into fuels. The target molecules of the processes being developed the methyl esters of fatty acids (FAME) derived from the direct esterification of lipids/oils which can be further exploited for biodiesel production. Finally, in the third approach household food waste (HFW) is used as feedstock for energy and biogas generation via MET and AD respectively. After subjected to water extraction HFW results to a liquid fraction (extract) and a solid residue. The extract is treated via a MFC for direct energy production whereas extra energy is recovered by the solid residue in the form of methane via AD.

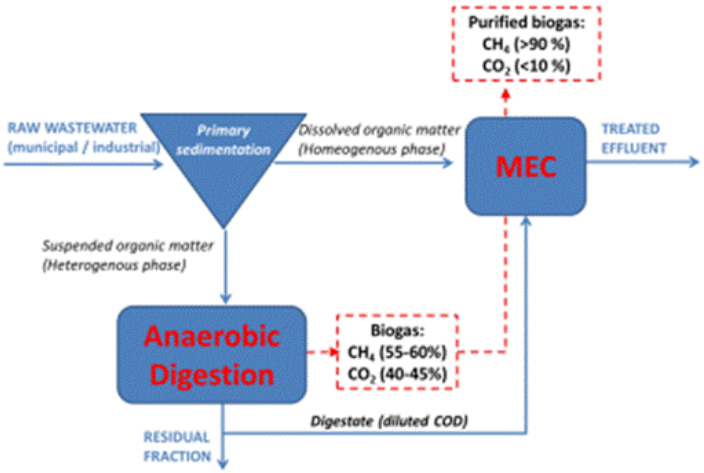

Figure 1. Integration of MET with AD for post treatment of digestate and biogas purification

WE-MET project is planned to produce promising results to alleviate the shortcomings of existing status in the MET, through a well-planned combination of basic research and engineering process development activities. Research partners and SMEs with different expertise will cooperate closely in order to develop novel MFC and MEC technologies. LCA analysis and pilot scale demonstration of the proposed schemes will further be used for the validation.

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