ENVIRONMENTAL SUSTAINABILITY OF TWO BIOLOGICAL TREATMENTS FOR THE ORGANIC WET FRACTION OF MUNICIPAL SOLID WASTE

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The wet organic waste is an important fraction of municipal solid waste (MSW), which in European Countries can reach values as high as 30-40% of the total amount of generated MSW. Its management requires an appropriate household source separation, an efficient separate collection, and a final biological treatment of anaerobic or aerobic digestion. It has been demonstrated that, in a life cycle perspective, anaerobic digestion (AD) process has a higher environmental sustainability than aerobic composting process [1]. The AD of the wet organic fraction of MSW (OF_{MSW}) is in fact able to minimize the greenhouse gas emissions and to produce a biogas for energy recovery. It is also characterized by the absence of emissions of bio-aerosols and bad odours, a limited utilization of land surface use, and a sufficient economic sustainability [2].

An interesting alternative to aerobic or anaerobic process units is that of an integrated anaerobic digestion plant, which includes a final aerobic treatment. This study aims to compare the environmental sustainability of this integrated solution with that of a “stand-alone” anaerobic process.

The integrated solution taken as reference is made-up of three phases: pre-treatment, wet anaerobic digestion (with a Continuous-flow Stirred-Tank Reactor), and a final stage of post-composting in bio-cells. The pre-treatment is a mechanical sorting process that efficiently removes the out-of-target material, making the OF_{MSW} a substrate suitable for AD. The thermophilic anaerobic phase generates two main products: a biogas, with a degradation rate of the volatile solids of 75%, and a solid digestate. The biogas, which is assumed to be composed by 60% of methane and 40% of carbon dioxide, is then burned in an internal combustion engine for electricity production, with a conversion efficiency of 34%. The digestate is dried and sent to the final aerobic phase to obtain a compost, which could be used as soil conditioner. The “stand-alone” anaerobic plant includes the same pre-treatment and AD phases, but it is not equipped with a final post-composting unit. The first configuration requires higher energy for the additional post-composting stage (which has been evaluated as equal to 20% of total electrical energy produced by biogas combustion), while the second configuration produces a lower quality stabilized material, then having a limited number of possible utilization.

Data collected in two plants in operations in Italy have been utilized to estimate the environmental burdens for the development of an attributional Life Cycle Assessment (LCA) study. The functional unit coincides with the treatment of 200 t/d (then about 60 kt/y) of OF_{MSW}. The system boundaries includes all the activities from the plant entry gate until the management of solid/liquid residues. The “system expansion” method was utilized to include the avoided burdens related to the recovery of energy and materials. It was assumed that the generated electrical energy replaces the production of electricity from the Italian grid. The compost produced in the integrated plant is assumed to substitute an amount of peat, which has been estimated assuming a carbon content of 20% for compost and 60% for peat. The digestate obtained from the “stand-alone” AD plant is not composted, and it is assumed to substitute inert materials for the operation of landfill capping, accordingly with Italian legislation.

The LCA results indicate that the “stand-alone” AD plant has better environmental performances. In particular, its larger energy recovery leads to better results in terms of midpoint impact categories of “Global Warming”, “Non-Renewable Energy” and “Respiratory Inorganics” [3]. The integrated plant shows worst results also in terms of “Land Occupation”, due to the necessity to add a non-negligible amount of a bulking agent (i.e. straw) to the digestate in order to guarantee the utilization of compost as soil conditioner. A sensitivity analysis has been carried out assuming that the compost generated by the integrated plant could be used as substitute of a chemical fertilizer, highlighting the importance of compost quality in the comparison between the two configurations.

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