

Waste refinery: A novel approach to municipal solid waste management through Life Cycle Analysis principles

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Abstract

The novel concept of the waste refinery is considered in this study as an alternative method for MSW treatment within the geographical region of Greece. The refinery sorts the untreated MSW through enzymatic liquefaction of the organic and paper fractions. The environmental performance of the refinery is investigated through the life cycle analysis (LCA) principles. The objective of this study is to evaluate the environmental performance of the waste refinery in comparison with MBT, source segregation and landfilling as far as the treatment of one (1) Greek MSW tonne in wet weight (functional unit) is concerned. The assessment is based on the two following principles: system expansion and zero burden approach.

An in-depth analysis of the environmental footprint of the four (4) examined scenarios was conducted. The waste management solutions that include electricity generation tend to have more avoided emissions, since the Greek electricity mix is mainly characterized by lignite power plants. This is depicted in the treatment of the organic fraction by the method of anaerobic digestion instead of aerobic digestion. Furthermore, since the feedstock for plastic production is fuel oils, recycling of plastic will mitigate the impact on human health, climate change and resources by a significant amount. Although Al is a small fraction in the Greek composition (0.9% ww), its recycling is a significant environmental mitigator since it mitigates the environmental impact of the energy intensive process of Al production from raw bauxite (bauxite ore - Bayer process - electrolysis of alumina). In what concerns the glass recycling, the respective production of glass is not characterized such an effective environmental impact indicator. The chosen recycling path for paper into corrugated cardboard did not have major CO₂ eq. savings, but it avoided emissions in the categories ecosystem quality and human health.

The consideration of the biogenic carbon binding to soil can enhance the savings in the accounted GHG emissions of a waste management concept. The landfilling scenario is a characteristic example. In specific, the landfill scenario performs saving emissions of about 40.6 kgCO₂ eq, instead of 360 kg CO₂ eq per tonne MSW direct emitted in the scenario without considering the carbon storage. Finally, it was proved that the waste refinery is the best performing scenario in the categories of human health, climate change and resources (62.4, 47.6, and 58.1 mPts respectively) and it has a better environmental performance than landfilling on the ecosystem quality, with minor savings of 0.3 mPts.