Environmental assessment of solid waste landfilling technologies by means of LCA-modeling

By using life cycle assessment (LCA) modeling, this paper compares the environmental performance of six landfilling technologies (open dump, conventional landfill with flares, conventional landfill with energy recovery, standard bioreactor landfill, flushing bioreactor landfill and semi-aerobic landfill) and assesses the influence of the active operations practiced on these performances. The environmental assessments have been performed by means of the LCA-based tool EASEWASTE, whereby the functional unit utilized for the LCA is “landfilling of 1 ton of wet household waste in a 10 m deep landfill for 100 years”. The assessment criteria include standard categories (global warming, nutrient enrichment, ozone depletion, photo-chemical ozone formation and acidification), toxicity-related categories (human toxicity and ecotoxicity) and impact on spoiled groundwater resources. Results demonstrate that it is crucially important to ensure the highest collection efficiency of landfill gas and leachate since a poor capture compromises the overall environmental performance. Once gas and leachate are collected and treated, the potential impacts in the standard environmental categories and on spoiled groundwater resources significantly decrease, although at the same time specific emissions from gas treatment lead to increased impact potentials in the toxicity-related categories. Gas utilization for energy recovery leads to saved emissions and avoided impact potentials in several environmental categories. Measures should be taken to prevent leachate infiltration to groundwater and it is essential to collect and treat the generated leachate. The bioreactor technologies recirculate the collected leachate to enhance the waste degradation process. This allows the gas collection period to be reduced from 40 to 15 years, although it does not lead to noticeable environmental benefits when considering a 100 years LCA-perspective. In order to more comprehensively understand the influence of the active operations (i.e., leachate recirculation, waste flushing and air injection) on the environmental performance, the time horizon of the assessment has been split into two time periods: years 0–15 and 16–100. Results show that if these operations are combined with gas utilization and leachate treatment, they are able to shorten the time frame that emissions lead to environmental impacts of concern.