CRITICAL CHOICES IN WASTE LCA – A CASE STUDY ON THE TREATMENT OF PAH-RICH ROAD DEBRIS

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Life cycle assessment (LCA) is well established to provide decision support on the design of waste management systems. It offers a holistic perspective on waste flows, treatment options and environmental impacts. Despite the holistic approach and the general relevance of LCA, it needs to be emphasized that results are context-specific and depend on the goal and scope of the LCA model as well as on the local conditions of the waste management system (Laurent et al. 2014a). Apart from the LCA setting, methodological choices and data availability play a crucial role for the validity and reliability of waste LCA results (Laurent et al. 2014b). Therefore, the effect of specific choices and assumptions on the results needs to be reflected by appropriate analyses, such as scenario, sensitivity and uncertainty analysis.

This study uses the case of treating German road debris rich in polycyclic aromatic hydrocarbons (PAH) to illustrate the effect of different LCA model choices on the environmental impacts associated with different treatment routes. Because PAH-rich road debris is designated as hazardous waste it cannot be directly utilized, but needs to be thermally treated before mineral aggregates can be recycled. Alternatively, it can be landfilled/used as a landfill construction material (after mechanical treatment). In this study, different thermal treatment options (all based on rotary kiln technology) for PAH-rich road debris generated in Kassel were compared among each other and with the two landfilling options. Material and energy balances as well as transport scenarios were established for each treatment path. Data for the foreground system was available from plant operators or collected from existing LCA studies. Background data was retrieved from ecoinvent Version 3.7. LCA modelling was performed using the open source LCA framework Brightway2 (https://brightway.dev/) and environmental impacts were expressed via 14 mid-point impact categories. In order to understand the effect of different choices, scenario and sensitivity analyses were performed. The variation of factors comprised transport distances and transport datasets, energy efficiencies of thermal treatment, and choices regarding the substitution related to produced heat and power as well as related to mineral aggregates and primary mineral raw materials. Furthermore, aspects of data quality associated with the assessment of existing (full-scale operation) vs. prospective (lab-scale experiments) technology were discussed. Major findings of the LCA were that energy-efficient thermal treatment of PAH-rich road debris is preferable to landfilling in 13 out of 14 impact categories. The exception was climate change, where the deposition at the landfill resulted in 3-times lower greenhouse gas emissions (around 20 kg CO_2-equ. per Mg of waste) than thermal treatment. For all the other impact categories thermal treatment with effective energy recovery performed better than landfilling, with particularly large advantages regarding human toxicity, ecotoxicity, and fossil resource depletion. With respect to thermal treatment, it was found that for the prospective technology options the uncertainty associated with the results outweighed the differences between the individual results for these prospective options. Critical factors in this context were energy efficiencies of the plants and substitution choices regarding electricity mix as well as primary materials. Also transport modes and distances turned out to have a relevant effect on the results. The effect of these choices highlighted that LCA results need to be interpreted in the context of the goal and scope as well the methodological framework of the study and that the general validity should not be overstated.

Literature:
Laurent et al. (2014a): Review of LCA studies of solid waste management systems – Part I: Lessons learned and perspectives, Waste Management 34. https://doi.org/10.1016/j.wasman.2013.10.045.
Laurent et al. (2014b): Review of LCA studies of solid waste management systems – Part II: Methodological guidance for a better practice Waste Management 34. https://doi.org/10.1016/j.wasman.2013.12.004.