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Probabilistic Life Cycle Assessment of the Nano Membrane Toilet

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Abstract : Developing countries are nowadays confronted with great challenges related to domestic sanitation services in view of the imminent water scarcity. Contemporary sanitation technologies established in these countries are likely to pose health risks unless waste management standards are followed properly. This paper provides a solution to sustainable sanitation with the development of an innovative toilet system, called Nano Membrane Toilet (NMT), which has been developed by Cranfield University and sponsored by the Bill & Melinda Gates Foundation. The particular technology converts human faeces into energy through gasification and provides treated wastewater from urine through membrane filtration. In order to evaluate the environmental profile of the NMT system, a deterministic life cycle assessment (LCA) has been conducted in SimaPro software employing the Ecoinvent v3.3 database. The particular study has determined the most contributory factors to the environmental footprint of the NMT system. However, as sensitivity analysis has identified certain critical operating parameters for the robustness of the LCA results, adopting a stochastic approach to the Life Cycle Inventory (LCI) will comprehensively capture the input data uncertainty and enhance the credibility of the LCA outcome. For that purpose, Monte Carlo simulations, in combination with an artificial neural network (ANN) model, have been conducted for the input parameters of raw material, produced electricity, NO_X emissions, amount of ash and transportation of fertilizer. The given analysis has provided the distribution and the confidence intervals of the selected impact categories and, in turn, more credible conclusions are drawn on the respective LCIA (Life Cycle Impact Assessment) profile of NMT system. Last but not least, the specific study will also yield essential insights into the methodological framework that can be adopted in the environmental impact assessment of other complex engineering systems subject to a high level of input data uncertainty.

Keywords : sanitation systems, nano-membrane toilet, lca, stochastic uncertainty analysis, Monte Carlo simulations, artificial neural network
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