Abstract

This study conducts a comprehensive assessment of the environmental and economic benefits of biogas production from leachate, employing a life cycle assessment (LCA) framework. Lakhodair dumpsite in Lahore was selected for the leachate collection, which receives 6000 tons of waste daily and produces large amount of leachate. The leachate collected was treated through a membrane bioreactor to produce biogas through anaerobic digestion. Using 1m3 of leachate, the system produced 350l of biogas and value-added products such as compost and metals. The environmental impact was evaluated using the LCA methodology, and the ReCiPe2016 Mid-point (H) approach, which has 18 different environmental categories. The results explain that terrestrial eco-toxicity, climate change, fossil depletion, and freshwater consumption were the main impact categories which are potentially contributed to 2.66E-01 kg 1,4-DB eq., 2.43E+01 kg CO2 eq., 3.26E-01 kg oil eq., and 5.52E+00 m3 to environmental degradation., respectively. The normalization (person per equivalent) analysis revealed that the resource category (fossil depletion) is the key contributor to environmental degradation. Scenario modeling was performed by replacing the power source with a solar cell rather than electricity from a grid mix. Hotspot identification was used to emphasize the effects of specific impact categories. The net present value (NPV) was calculated at 967,857.23 USD by assuming a discount factor of 10 % and an inflation rate of 5 % for 20 years. It also evaluated the economic viability of conversion schemes by calculating investment costs, operational expenses, and prospective revenue (82,926.48 USD per year). The findings show that converting waste leachate to biogas can provide significant environmental advantages and economic savings, demonstrating its potential as a sustainable waste management option. This study offers important insights for policymakers, waste management practitioners, and stakeholders who want to reduce environmental impacts while increasing resource recovery from waste streams.