Abstract

Every day, a large number of PET (Polyethylene terephthalate) bottles are thrown away once they have been used. As a result, there has been a growing focus on recycling bottles in recent years. This study aims to quantify the environmental and techno-economic assessment of the mechanical recycling of PET bottles. The life cycle assessment (LCA) approach was adopted to investigate the environmental impact of mechanical recycling of PET bottle waste. Impact assessments are carried out at both midpoint and endpoint levels. The industrial process comprises 5 major operational areas: collection and transportation, optical and manual separation, shredding, washing and drying, extrusion, and palletization. The functional unit is selected as 1 ton of PET bottle waste recycling. All the inputs and outputs are calculated based on the selected functional unit. The key findings indicate that climate change, terrestrial ecotoxicity, fossil depletion, and ionizing radiations were the primary midpoint categories, potentially contributing 3.81E+02 kg CO2 eq., 1.40E+02 kg 1,4-DB eq., 1.39E+02 kg oil eq., and 1.74E+01 kg 1,4-DB eq. respectively. The normalization results (person equivalent) showed that the resource reduction categories (fossil and metal depletion) are the primary factors contributing to environmental degradation. Scenario modeling was conducted using a grid mix as a source of electricity which resulted in a decrease in terrestrial ecotoxicity potential, metal depletion, ionizing radiation, marine ecotoxicity, and marine eutrophication. The Net present value (NPV) was computed as USD 676,756.55, based on a 10% discount rate and a 5% inflation rate for 20 years. The total revenue generation from the mechanical recycling of PET bottle waste was 74,048.618 USD/year. This research yields significant benefits to the environment, as mechanical recycling of PET bottle waste emerges as a cost-effective and energy-efficient approach. By diverting PET bottle waste from landfills and incineration, mechanical recycling mitigates pollution, reduces the consumption of raw materials, and promotes the circular economy.