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Environmental Life Cycle Assessment for Solid Tire Manufacturing: A Case Study from Sri Lanka

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Abstract

The global solid tire market is valued at USD 6.81 billion in 2024, with Sri Lanka contributing 28.6% of world exports. Despite this industrial significance, literature regarding the specific environmental implications of solid tire manufacturing, which involves specialized molding and energy-intensive curing remains limited. This research assesses the environmental impacts of Sri Lankan solid tire manufacturing following the ISO 14040/44 framework. A cradle-to-gate approach was implemented, defining the functional unit as the manufacturing of one metric ton (1 MT) of industrial solid tire, explicitly excluding downstream product use and end-of-life phases. The assessment utilized SimaPro (v10.2) and the Ecoinvent (v3.9) database, employing the ReCiPe 2016 Midpoint (H) method with calculation setup CML-IA baseline V3.11 / EU25 to analyze 18 distinct impact categories. Results indicate that producing 1 MT of solid tires generates a Global Warming Potential of 2,770 kgCO_2-equivalent. However, significant burdens were also identified in Marine Aquatic Ecotoxicity (the highest impacted category), abiotic depletion (fossil fuels), and human toxicity. Raw material production accounts for 58% of total lifecycle impacts, driven largely by synthetic rubber (13%) and carbon black (18%), which are heavily concentrated in supply chains from China and India. Conversely, manufacturing operations are the primary driver for climate change impacts (45%), specifically due to energy consumption in curing operations. The study concludes that while renewable energy adoption can mitigate climate impacts by 30-50%, it must be paired with material circularity strategies. Recommendations include prioritizing bio-based synthetic rubber and recovered carbon black to address toxicity and depletion hotspots, alongside immediate supplier engagement.

Keywords: *E-LCA, Solid tire, Sri Lankan industries, Environmental hotspots, Cradle-to-gate*