

Resilient Hazardous Waste Management in Malaysia: Circular Economy Strategies and Digital Technology Opportunities

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Abstract:

Hazardous waste management is an increasingly critical sustainability challenge in rapidly industrialising economies, where rising waste volumes, uneven treatment capacity and weak enforcement can intensify environmental and public health risks. This study examines Malaysia as a developing-country case and proposes a resilient hazardous waste management pathway by integrating circular economy principles with emerging digital technologies. A mixed-method approach was employed, combining literature and policy review, stakeholder-informed analysis, SWOT assessment, bibliometric mapping, GIS-based spatial analysis of treatment facilities, and trend analysis of national hazardous waste data up to 2024. The findings reveal that hazardous waste generation in Malaysia peaked at 7.51 million tonnes in 2021, before declining steadily to 5.92 million tonnes in 2022, 5.84 million tonnes in 2023, and further to 5.38 million tonnes in 2024, indicating a post-peak adjustment while still exerting significant pressure on existing treatment infrastructure. GIS analysis further reveals a pronounced concentration of treatment facilities in West Malaysia, while East Malaysia remains comparatively underserved despite its industrial importance, increasing transport burden, cost, and environmental risk. The study also identifies persistent barriers related to