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Plastic Waste Management in the EU: Machine Learning and Data Mining for Classifying and Evaluating Treatment Patterns and Determinants

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Abstract

Waste management is a critical environmental and economic challenge for the European Union (EU), requiring effective policies and sustainable treatment methods. Plastic waste, in particular, is one of the fastest-growing waste streams, driven by increasing consumption and its widespread use in logistics due to its lightweight and cost-

effectiveness. Its environmental impact makes it a pressing issue requiring advanced waste management strategies.

This study explores waste treatment strategies across EU countries by applying machine learning (ML) and data mining (DM) techniques to classify and analyse different waste management models. Using a dataset of key indicators, we examine waste generation, recycling rates, landfill utilisation and energy recovery, along with organisational ones such as the adoption of deposit return schemes and economic factors such as GDP or environmental expenditure. By employing clustering and classification algorithms, we identify patterns in waste management performance and group countries accordingly. The results reveal distinct approaches to waste treatment, highlighting both best practices and inefficiencies across member states..

Our analysis is framed within the regulatory context of the Waste Framework Directive (Directive 2008/98/EC) and the Packaging and Packaging Waste Directive (Directive 94/62/EC), which establish the principles of the waste hierarchy, extended producer responsibility, and recycling targets to promote a circular economy. The study provides insights into data-driven decision-making, enabling policymakers to optimize waste treatment strategies in alignment with these directives. Our findings emphasize the potential of ML and DM in enhancing waste management efficiency and sustainability in the EU, contributing to the objectives of waste prevention, resource efficiency, and environmental protection.

Keywords: waste management, data mining, machine learning