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Modern Approaches to E-Waste Recycling and Recovery in Mandya

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Abstract - Today, developments in technology have changed everyone's lifestyle. Although this innovation is beneficial, it creates serious effects on human health and environmental health. One of the main reasons for this is "E-waste" from electronic products. The use of electronic products worldwide has increased the amount of "E-waste" or electronic waste, which has now become a serious problem. Improper disposal of e-waste has now become an environmental and public health problem in the world's cities.

Therefore, correct classification and management of e-waste requires the recovery of important information about e-waste. This growing e-waste is inherently hard and rich in metals such as neodymium, indium, palladium, tantalum, platinum, gold, silver, lead and copper, which can be recovered and brought back into the cycle of production and daily use. In this project, a deep learning model is used to identify e-waste using image processing. The design model, on the other hand, selects the waste with good accuracy and takes less time. Wastes are divided into two groups according to the amount or value in the waste. By using this model effectively, we can solve e-waste management problems, improve recycling and contribute to environmental sustainability.

***Key Words*:** E-waste management, Electronic waste recycling, Sustainable waste management, Mandya e-waste recycling, Waste reduction and recovery, E-waste collection and segregation, Advanced recycling technologies

1. INTRODUCTION

Proper management of electronic waste (E-Waste) is becoming increasingly critical with the growing amounts of such waste globally. Although E-Waste contains highly valuable materials for recycling, it can also contain hazardous substances like mercury, lead and cadmium. Therefore, developing efficient systems for collecting, sorting and treating e-waste is essential. This paper examines the concept of using image recognition technology to improve e-waste management efficiency. The system considered is based on the analysis of visual data obtained by photographing waste objects. The aim is to facilitate the identification and classification of e-waste through a simple user interface, considering the ubiquity of smartphones and easier Internet access. This innovative approach allows individuals to send a photo of the waste object to collection companies via an app or server, where the waste type would be automatically identified using image recognition technology. The core component of this approach is the application of deep neural networks, specifically deep convolutional neural networks (CNN), for image analysis. The first stage involves waste type classification, for which a deep convolutional neural network is used. CNN is an architecture designed to extract complex features from images and learn to distinguish them according to certain criteria. This technique enables reliable classification of different e-waste categories with significant accuracy.

The second key component is the faster Region Convolutional Neural Network (R-CNN), an advanced object detection technique in images. This network enables the recognition of equipment category and size estimation from e-waste photographs. Integrating R-CNN into the system allows more detailed understanding of waste components in images, which is essential for successful waste management. In today's digital age, electronic devices have become an essential part of everyday life. However, the rapid pace of technological advancement has led to a significant increase in electronic waste (e-waste), posing a serious threat to the environment and public health. Mandya, a district in Karnataka known for its agricultural prominence, is also experiencing the challenges of managing growing amounts of e-waste due to increased urbanization and digital penetration. This project explores the modern approaches being adopted in Mandya to tackle the issue of e-waste recycling and recovery. With a focus on sustainable practices, technological innovation, and community participation, Mandya is gradually moving towards effective and eco-friendly e-waste management. The aim of this study is to understand the current methods used in the district, assess their impact, and explore opportunities for improvement and scalability. By analyzing the roles of local authorities, private sectors, and the public, this project sheds light on how modern strategies-such as smart collection systems, eco-friendly recycling techniques, and awareness campaigns-are contributing to a cleaner and more sustainable Mandya. The 21st century is marked by an unprecedented reliance on electronic devices. From smartphones and laptops to refrigerators and televisions, modern living is deeply interwoven with technology. While these devices enhance quality of life and drive economic growth, their lifecycle ends in a form of waste that is often overlooked—electronic waste, or e-waste.

E-waste comprises discarded electronic appliances, components, and devices, many of which contain hazardous substances such as lead, mercury, cadmium, and brominated flame retardants. At the same time, e-waste is a rich source of valuable materials like gold, silver, copper, and rare earth elements. Globally, e-waste generation was estimated at over 57 million tonnes in 2021, and the number is projected to rise steadily. Unfortunately, only about 20% of this waste is formally recycled, while the rest ends up in landfills or informal recycling sectors that operate under unsafe and unregulated conditions. In India, the e-waste scenario is rapidly evolving. With a growing middle class and increasing digital penetration, India is now the third-largest generator of e-waste globally. According to a report by the Central Pollution Control Board (CPCB), India generated approximately 1.7 million metric tonnes of e-waste in 2019–20. However, less than 25% of it is formally collected and processed. The remaining waste is either stored at homes or handled by the informal sector through crude methods that harm both the environment and human health. Mandya, a district located in the southern part of Karnataka, is traditionally known for its sugarcane production and strong agrarian economy. However, like many other semi-urban districts in India, Mandya is now witnessing rapid infrastructural and digital development. The proliferation of electronic goods in households, educational institutions, and businesses has led to an increase in e-waste, creating a need for efficient and sustainable management systems. Although Mandya may not be a major industrial hub, it serves as a critical junction between rural and urban Karnataka. As rural populations begin to adopt more electronic devices, the district finds itself at a tipping point where proactive measures can prevent future environmental damage. Local governance bodies, schools, startups, and environmental activists are starting to recognize the importance of sustainable e-waste management. However, the approaches remain fragmented, with much room for innovation, collaboration, and systematization. Traditional

2 METHODOLOGY

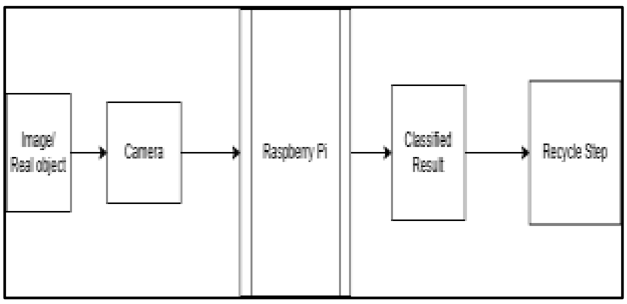

Fig-1: BLOCK DIAGRAM

E waste collection -scan e waste through camera -scanned image procced by ML algorithm(CNN) -result displayed.This project aims to address e-waste management by utilizing a camera-based system integrated with machine learning. The system scans waste items through a camera, capturing their images. These images are then processed using a Convolutional Neural Network (CNN), a powerful ML algorithm, to identify and classify the stype of e-waste. The classification results are displayed, enabling users or systems to segregate e-waste efficiently. This innovative approach enhances waste sorting accuracy, promotes proper recycling, and reduces environmental harm caused by improper disposal. The project demonstrates the practical application of AI in solving real-world problems while fostering sustainability through effective e-waste management. The study employs a mixed-method approach that combines both primary and secondary research techniques to explore modern approaches to e-waste recycling and recovery in Mandya. Primary data was collected through surveys and structured questionnaires distributed to households, students, local business owners, and electronic retailers in the region. These tools were used to assess awareness levels, disposal practices, and community willingness to participate in e-waste management programs. In addition, in-depth interviews were conducted with key stakeholders such as municipal officials, informal waste handlers, NGO representatives, and educators to gain qualitative insights into the challenges and opportunities in the current e-waste ecosystem. Secondary data collection involved a comprehensive review of government documents, environmental reports, policy frameworks, and academic literature. Key sources included publications from the Central Pollution Control Board (CPCB), the Karnataka State Pollution Control Board (KSPCB), and research papers on national and global e-waste management practices. Field visits were carried out in Mandya to observe local e-waste handling practices firsthand. These included visits to scrap shops, informal dismantling areas, municipal dumps, and schools to identify existing gaps and potential points for intervention. Observations were documented through notes and photographs, providing contextual information to support survey findings.

The collected data was then analyzed using both quantitative and qualitative methods. Statistical tools were used to tabulate and interpret survey results, while thematic analysis helped categorize responses from interviews and field observations. A comparative study was also undertaken to analyze the differences and similarities between Mandya's current practices and those followed in more developed regions such as Bengaluru, as well as successful international models in countries like South Korea and Switzerland. Based on these findings, a localized e-waste management model was proposed. The model emphasizes community participation, educational outreach, public-private partnerships, and the integration of simple, eco-friendly recycling technologies. To ensure practicality and acceptance, preliminary proposals were shared with select community members and local officials for feedback, which was incorporated into the final recommendations. The study concludes with a detailed report that includes data analysis, proposed action plans, and visual representations such as charts, maps, and system diagrams to support a holistic understanding of the issue.

3 WORKING PRINCIPLE

In this project firstly we collect the e waste by approaching the customer through cash payment and collecting in school, colleges and electric shops. Then we recover the obtained materials in that e waste and recycling process s done on depending on the object. Collects user input for an e-waste pickup. Computes the payment based on type and quantity. Sends a confirmation SMS using Twilio . User-friendly registration of e-waste contributions. Reporting for data tracking. Recycling education with clear, item-specific procedures. You get a comparative bar chart showing how well each recycling method recovers different metals from the same e-waste batch. Represents a batch of e-waste with amounts (in grams) of various metals.

The code loops over each method and each metal, calculating the recovered mass using, creates a bar plot that compares how much of each metal is recovered using each method. X-axis: Metal types. Y-axis: Recovered mass in grams.Different colors: Different recovery methods. To compare the effectiveness of three metal recovery methods based on how much of each metal they can recover from the same batch of e-waste. Useful for decision-making in recycling processes to choose the most efficient or economical method depending on the metal.

4 RESULTS

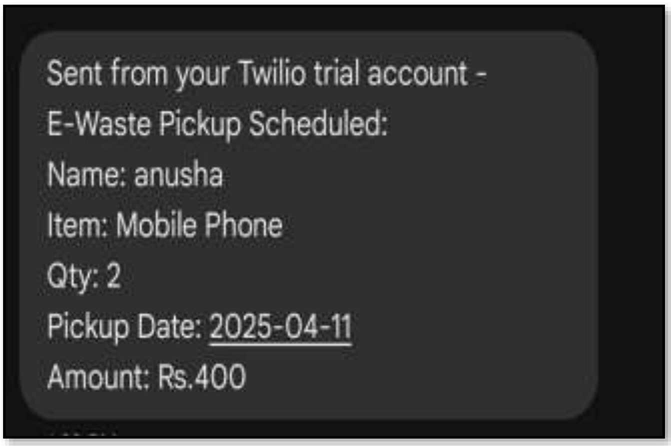

Fig-1: consumer receiving the message

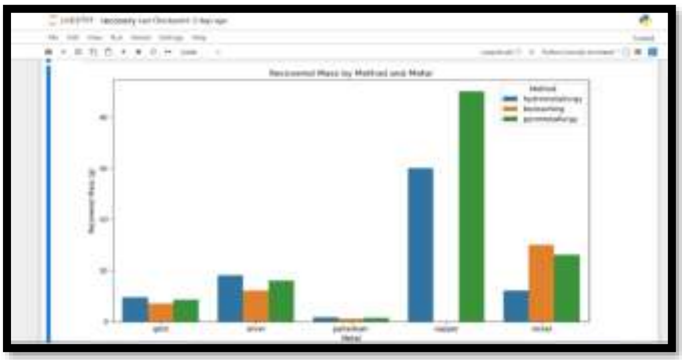

Fig-2: Analyzing recovery by graph

X-axis (horizontal): Different metals — gold, silver, palladium, copper, and nickel. Y-axis (vertical): Recovered mass (probably in grams or another unit, but it's just labeled "Recovered Mass [g]" here). Colored bars represent different recovery methods:

Blue = Hydrometallurgy,

Orange = Bioleaching

Green = Pyrometallurgy

Gold: Recovered in small quantities by all three methods, with pyrometallurgy recovering slightly more.

Silver: Recovered decently by all three methods, hydrometallurgy slightly leading.

Palladium: Almost negligible recovery across all methods.

Copper: Huge difference - pyrometallurgy recovers the most copper, followed by hydrometallurgy; bioleaching is minimal.

Fig-3:Recycling Process

5 CONCLUSIONS

The effective management of e-waste is a critical issue that requires immediate attention in Mandya. The traditional methods of e-waste disposal are no longer sustainable and pose significant environmental and health risks. Modern approaches to e-waste recycling and recovery offer a sustainable solution to this problem. The implementation of advanced recycling technologies, such as mechanical separation, Hydrometallurgical processing, and pyrometallurgical processing, can significantly improve the efficiency and effectiveness of e-waste recycling in Mandya. Additionally, the adoption of circular economy approaches, such as design for recyclability, can reduce the amount of e-waste generated in the first place. The success of modern approaches to e-waste recycling and recovery in Mandya will depend on the collaboration and coordination of various stakeholders, including government agencies, private sector companies, and civil society organizations. It will also require significant investment in infrastructure, technology, and human resources. However, the benefits of modern approaches to e-waste recycling and recovery in Mandya far outweigh the costs. These benefits include the creation of new jobs and economic opportunities, the reduction of environmental pollution and health risks, and the conservation of natural resources. In the end, the effective management of e-waste is not only a moral imperative, but also an economic and environmental necessity. Modern approaches to e-waste recycling and recovery offer a sustainable solution to this problem and can help to create cleaner, greener, and more prosperous future for the people of Mandya.

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