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Sorting of Solid Waste in Tehkal and University Town Peshawar City, Pakistan

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Abstract: ***Fixed waste sorting plays an important role in achievingefficient waste management, especially when it comes to recyclable materials such as paper. Effective sorting of waste not only promotes ecological sustainability but also provides valuable resources. This paper is one of the broadest materials that providesefficient separation of other waste types and maximizing recycling efforts. This article presents a details analysis of the paper waste sorting process focusing on the various methods using manual separation and mechanical sorting techniques. However, some challenges prevent humans from maximizing the chances of organizing waste. This study explores the waste stream in a local neighborhood through a series of observations at Kabari (recycling) shops, aiming to uncover the types and quantities of waste being collected daily. By conducting interviews with shop incharges and gathering data over multiple days, a rich dataset was compiled, reflecting the flow of recyclable materials in the area. The waste categories studied included paper, plastic, metal, and glass, with quantities meticulously tracked each day. Through statistical analysis and graphical representation of the data, we identified key trends in the waste composition of the locality. Notably, plastic emerged as the dominant waste type, outpacing paper and metal in terms of volume. These findings highlight the critical need for targeted waste management strategies that focus on the most prevalent materials. This study not only provides insights into the local recycling landscape but also offers actionable data for policymakers, waste management professionals, and environmental advocates to optimize recycling efforts, reduce landfill dependency, and promote sustainable urban waste solutions.***

Keywords: Waste Sorting, Recycling, Paper Waste, Waste Management, Environmental Sustainability

I. INTRODUCTION

Sorting is the process of separating and storing various wastecomponents. Waste must be sorted to improve both the amount and quality of recyclable materials. Everyone can contribute to efficient waste separation regardless of household size or the amount of commercial waste. Waste sorting is the waste classification process in groups based on recyclable materials.Waste management is extremely important for sustainability, particularly when it comes to managing complex waste flow such as sediments from construction. As a rule, two main techniques are used to sort waste mechanical sorting and manual sorting.Everyone has their advantages and disadvantages. The manual process is the process in which human workers physically process and separate materials according to the size, types, and suitability of recycles. Its accuracy and feasibility make it possible to use in complex or mixed waste. Despite itsextreme accuracy, versatility, and low furniture cost, it is slow labor extensive and dangerous for the health and security of implies. Mechanical sorting is more reliable, making it ideal for large-scale operations. However, maintenance costs, substantial capital investments, and reduced flexibility in complex waste flow. Both mechanical and manual sorting are often combined with the integrated approach of modern waste treatment systems. The advantages of both approaches are combined in this hybrid system to improve recycling speed, reduce contamination, and improve screening efficiency. Guaranteed speed and accuracy make it particularly good when dealing with a variety of waste.

Mechanical sorting promotes the separation and recovery of valuable recyclable materials such as plastics, metals, and papers from mixed waste whichsupports the transmission of the circular economy. Despite environmental benefits such as reducing the need for combustion and landfill, mechanical sorting is offset against some persistent challenges. A more stringent and transparent assessment of the mechanical sorting process is required to improve the effectiveness of the recycling system and the overall resource recovery improvement. This article examines the current state of mechanical screening technology challenges to improve environmental output, and potential solutions(Tanguay-Rioux, Spreutels et al. 2022).For the most urgent concern of municipal solid waste recycling systems, there is the decision on the appropriate screening techniques.

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These articles examine trends in developing systems and methods for sorting MSW.This will focus on human operator integration as a result of identifying materials during the screening process.This explains the different configurations of row sorting and evaluates the effectiveness of these methods., taking into account actual reasonable applications. A combined approach has been proposed that uses both manual and automated sorting techniques to maximize efficiency and ensure higher recyclable rates. These finding aims to optimize the experts in the field of waste management in optimizing sorting strategies to rehabilitate resources and improve sustainable waste (Lemeshko and Semenov 2024). Construction and demolishing(C&D) waste is caused by activities such as construction, transformation, demolition of buildings, and environmental disasters. This waste usually includes materials such as concrete, wood,metals,glass,and gypsum which can account for 15-20% of urban fixed waste in some areas. The composition of C&D waste has developed over time as the presence of synthetic materials and metals increases which causes concern about environmental impacts and shortage of raw materials, improper disposal of R&D wastes, such as illegal dumping, tightens these issues and threatens landfills. However, the profitability and effectiveness of recycling depend on a variety of factors including regularity guidelines, technology, an,d project management practices. This study also includesa cost-benefit analysis to assess the economic feasibility of the C&D recycling program for private sector participation. This study uncovers the importanceofsustainable building practices and the role of recycling against the growing challenges of C&D waste management (Huang, Lin et al. 2002). In a waste sorting system, deviations such as broken devices and false sampling can lead to significant differences, particularly in the case of procedures such as beverage cartons, so maintaining consistent operation parameters of accurate data is important. Optimization should improve this vulnerability through methodological modeling and appropriate assumptions. Conditions that can't be reproduced, such as partially non-observational manual sorting and incorrect devices, lead to uncertainty. Material distribution is also required as reliable results rely on a consistent flow of material data or underwearunits can distort the data. As long as the system is mathematicallydetermined, modeling systems are inversecollegesthat can help evaluate untested sections and fill information gaps. A decision tree is a useful tool to reduce uncertainty, maximize plant operation, and asses how preparation affects reliability (Feil, Pretz et al. 2017). (Riasat 2025)addresses local recycling practices in the Rawalpindi Pakistan areas and evaluates economic activities related to the collection of scrape waste known as cover drops in Pakistan. They attempted to determine current community recycling practices and examine the economic impactof collecting scrap waste. Six scrap dealers were selected as a respondent to in depth interview as a part of the study. They used qualitative methodology and targeted samples over the course of a month. According to theirstudy, collecting scrape waste gives people the opportunity to unemployed and illiteratework, particularly for jobs such as sorting, processing, and sending scrap materials. Aluminum scrap was the most profitable for these workers. Overall their study highlights the economic importance of collecting scrape waste and the success of recycling initiatives in the neighborhood,supportingresource recovery and waste management in the Rawalpindi Pakistan region (Riasat 2025). (Hatayama, Daigo et al. 2012)evaluates the outlook for aluminum recycling by 2050. This takes into account scrape classification techniques. (Eklund, Kihlstedt and Engkvist 2010) Addresses the characteristics, experiences, and difficulties of Swedish recycling center users. The results highlight the need for more time and better information, thereby focusing on increasing celerity in waste sorting.

This study aims to analyze the composition and quantity of recyclable waste collected in a local neighborhood by observing Kabari (recycling) shops, in order to identify key trends in waste generation and provide data-driven insights to inform effective and sustainable waste management strategies.

II. RESEARCH METHODOLOGY

A. Study Area

Tehkal and Abdara Road are two important locations in Peshawar, Pakistan, and are part of the research field of the study. These locations were selected for their importance related to the city recycling and waste management guidelines. Living and Hemi-commercial is known for its various factory production patterns. Thispattern includes many scrap, commercial, and household materials. Abdara Road is a well-known highway that is extremely important for waste collection, especially scraps waste collection due to its busy market area and advanced commercial activities. These represent areas with a mix of different waste generation types and residential and commercial real estate, so these areas were selected to assess local recycling practices and economic impact on the community. By focusing on these areas, this study hopes to provide a complete understanding of the recycling and waste dynamics in Peshawar city and provide important insights into local waste management tactics.

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B. Sampling

This study used targeted sampling technology. This is not a probability sample method that is often used to select participants who have specific knowledge or experience that is often used in qualitative research to provide a deeper understanding of the dynamics of scrape waste and recycling collections. The main goal of this study was to collect incoming insights so a sample size for 5 scraper dealers was selected. Data saturation of points where new information is not revealed was achieved by these five respondents,and this sample size is suitable for qualitative studies. The selected dealers served as important informants and gifts to help them gather information about the relevant economic activities of these communities as well as local recycling and scrap collection.

C. Method

To obtain thorough information about sorting of waste in the study area the daily life and activities related to recycling and scrapping were observed for a day. Because this study is inevitably qualitative, unstructuredinterviews were used to allow for a more flexible and open investigation of the study. The discussion was overseen by an interview guide that included unresolved questions that asked participants to learn more about theirperspectives and experiences rather than giving yes or no answers. Filed notes were also included in the interview book to support the data collection process. Each interview period was 1-2 hours giving participantssufficient time to discuss details about the local scrap process and financial activities to collect scrap.

D. Scrap Material and Sorting Process

An important part of the recycling operation is the collection and sorting of scrap materials. This procedure was thoroughly explained in interviews with five local, scrap dealers and manual sorting workers to provide insight into the procedure, difficulties, and practical aspects of waste sorting in the industry. This section provides an overview of the techniques used by dealers and workers. These are sorted and managed on a daily and weekly basis by dealers and workers.

1) Collection Of Scrap Materials

Sorting of waste starts from the collection of scrap materials. Scrap dealers collect waste from a variety of sources including,commercial,industrial, and residential sectors. The materials collected are woven,paper, and plastics. Scrap is often collected in large quantities by handing over defined collection centers or direct collections. According to dealers, the majority of private scrapes are featured regularly or in response to specific inquiries. Additionally, some retailers offer buyback programs to go to residential buildings and branches to purchase scrap directly. The current pickers of factories or storage that produce substantial quantities of metals, electronic, and industrial wastes are part of the large collection. These materials are often made up of scrap copper, aluminum, and iron. After transporting to the central location, the scrap is manually sorted.

2) Sorting of scrap materials

The most popular sorting is manual sorting. Workers classify waste according to type composition and condition. The sorting process involves careful identification and separation of materials to ensure that all types of materials are properly processed for recycling. This study examines many plastic sorting strategies and highlights both automated and manual approaches (Ruj, Pandey et al. 2015).

- First sorting: workers begin their first sorting level when scrap material is discharged at the sorting station upon arrival. This includes sorting large objects such as cardboard, plastic containers, and scrap metals.
- Second sorting: After initial separation, the materials are further divided into different groups for example, metal scraps are divided into subcategories without dealing (such as copper aluminum) and iron (iron-based). PET AND PVC are one of the types of sorted plastics.
- Manual work: The workers manually inspect all elements to determine their material composition. They often work in teams.Packages with wires, cables, outdated devices, and mixed materials are some of the elements that are properly dissembled and placed. To prevent contamination of the materials, this process requires careful handling and accurate details.
- Recycled Containers: After sorting the materials are placed in different containers or stakes according to their categories. Depending on the types of materials, these sorted materials are either provided directly to the buyer for sale or transported to the recycling system.

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Example of scrap yard godown at Abdara Road Peshawar:
It contains mixed feedstockandthe sorting of waste takes place with the help of two labors Figure 1.



Figure 1 depicts the scrap yard godown.

Shredding and magnet sorting: To improve the effectiveness and accuracy of the recyclable process many scrap dealers in the region include both shred and magnet sorting techniques in their business. Shredders allow for large, heavy objects such as cars, metal scrapes, and outdated devices allowing them to quickly disassemble them into smaller, easier, and more accessible pieces. In addition to allowing for more effective sorting, this initial size reduction of the material makes it easier for the material at later stages. This dual strategy is combined with magnet reordering in which a strong magnet separator from mixed waste removes ferrous metals such as steel and iron greatly improving material recovery. With the effective separation of ferrous metal of non–iron materials, magnetic sorting reduces pollution and improves the purity of the materials.

III. RESULTS (ANALYSIS OF MANUAL SORTING PRODUCTIVITY: DAY-WISE OVERVIEW)

The manual sorting productivity was monitored over four days, focusing on five key materials: scrap steel, papers, tin bins, plastic bottles, and dry bread. The performance was evaluated in terms of the quantity sorted per person per day (kg/person/day). Below is a day-wise summary and an overall productivity assessment:

1) Day 01:

On the first day, the highest quantity sorted was papers (25 kg/person/day), indicating ease of identification and segregation. This was followed by tin bins (15 kg) and plastic bottles (13 kg). Dry bread (10 kg) was moderately sorted, while scrap steel (2 kg) had the lowest collection rate, possibly due to its lower presence or difficulty in manual handling as shown in Table 1.

Table 1 showcases the manual sorting productivity on Day 1.

Day 01		
S.NO	Material	Kg/person/day
1	Scrapsteel	2
2	papers	25
3	Tinbins	15
4	Plastic bottles	13
5	Dry bread	10

2) Day 02

On the second day, scrap steel improved noticeably (5 kg/person/day), which might be attributed to better sorting strategies or increased availability. However, papers decreased to 18 kg, possibly due to supply variation. Tin bins (16 kg) slightly increased, while plastic bottles remained consistent at 13 kg.

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Dry bread decreased to 5 kg, showing variability in organic waste availability, as shown in Table 2.

Table 2 showcases the manual sorting productivity on Day 2.

Day 02		
S.NO	**Material**	**Kg/person/day**
1	Scrap steel	5
2	papers	18
3	Tinbins	16
4	Plastic bottles	13
5	Dry bread	5

3) Day03

Day three showed moderate performance across all materials. Papers maintained a good level at 20 kg, and scrap steel was at 2.5 kg, close to the day one value. Plastic bottles (10 kg) and dry bread (6 kg) showed slight decreases, while tin bins (13 kg) dropped compared to previous days, indicating fluctuations in waste stream composition as shown in Table 3.

Table 3 showcases the manual sorting productivity on Day 3.

Day 02		
S.NO	**Material**	**Kg/person/day**
1	Scrap steel	2.5
2	papers	20
3	Tin bins	13
4	Plastic bottles	10
5	Dry bread	6

4) Day 04

The fourth day recorded one of the most balanced sorting outputs. Papers again peaked at 25 kg, reaffirming their abundant presence. Plastic bottles (15 kg) reached their highest point during the observation period. Scrap steel (3 kg) and tin bins (15 kg) remained steady, while dry bread (10 kg) returned to the day one value, indicating variability but potential predictability in organic waste as shown in Table 4.

Table 4 showcases the manual sorting productivity on Day 4.

Day 04		
S.NO	**Material**	**Kg/person/day**
1	Scrap steel	3
2	papers	25
3	Tinbins	15
4	Plastic bottles	15
5	Dry bread	10

Average Productivity Overview:

To provide a clearer picture, the average productivity over the four days is summarized in Table 5 and Figure 2. From the average data:

- Papers emerged as the most consistently and abundantly sorted material.
- Tin bins and plastic bottles followed, reflecting their frequent occurrence and ease of sorting.
- Dry bread, an organic component, showed significant day-to-day variation, likely due to inconsistent waste generation patterns.
- Scrap steel, while important, had the lowest average, suggesting limited availability or difficulty in manual separation.

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The manual sorting productivity data highlights the dynamic nature of waste composition and the importance of day-to-day tracking for resource optimization. Papers, tin bins, and plastic bottles contribute most significantly to the daily sorted waste, suggesting targeted strategies could further enhance efficiency. Monitoring such trends not only improves recycling rates but also informs workforce allocation and equipment planning.

Table 5 shows the average manual sorting productivity over the four days.

Day 04		
S.NO	Material	Kg/person/day
1	Scrapsteel	3.125
2	papers	22
3	Tinbins	15
4	Plastic bottles	12.8
5	Dry bread	7.8

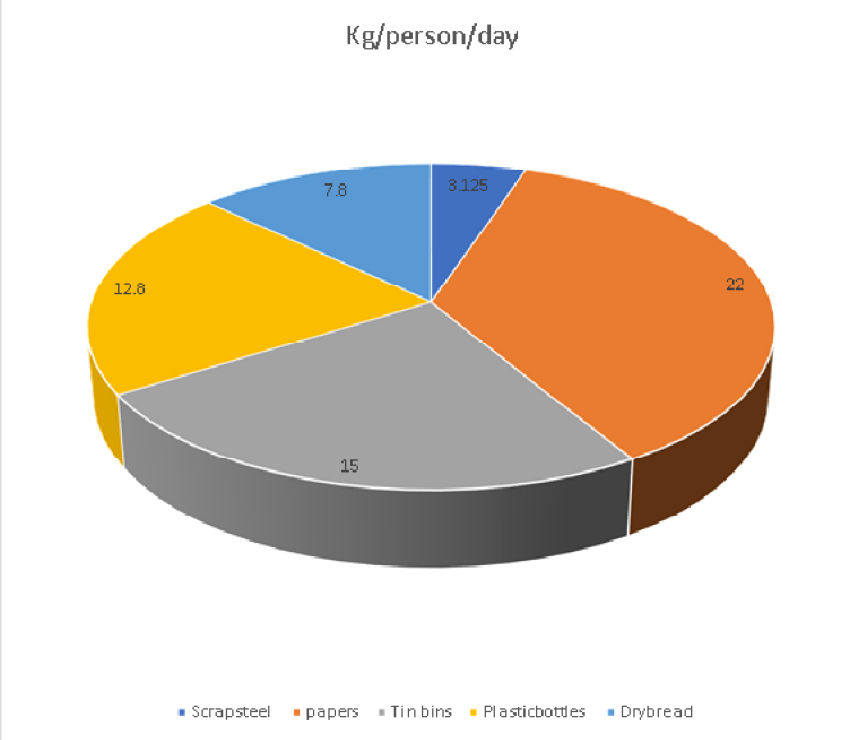


Figure 2 showcases the average manual sorting productivity over the four days.

Several important trends highlighting variations in manual sorting efficiency in response to material characteristics, workers' experience, and operational changes are revealed by analyzing the 4-day productivity sorting. The efficiency of sorting was greatly influenced by the properties of the materials used. Lighter, more uniform materials such as paper continue to show higher productivity than bulky or irregular materials such as dry bread and steel. Variations of plastic bottles and scraps of steel show the worker-learner curve. Their improved sorting techniques and stronger familiarity with the materials led to improved performance. However, on some days, the difficulty in handling materials of different sizes, weights, and conditions was less productive due to its inherent nature Particularly stabilizing and adaptation were visible in the course of the sorting process. The analysis conclusion highlights how important it is to implement more effective sorting techniques and operational tactics to increase the general effectiveness and efficiency of the manual sorting process in the scrap recycling process.

IV. CONCLUSION & RECOMMENDATION

As urban populations continue to grow, efficient waste management has become a critical component of sustainable development. This study examined the waste stream in a local neighborhood through detailed observations at Kabari (recycling) shops. By conducting interviews with shop incharges and collecting data over multiple days, a comprehensive dataset was compiled to reflect the daily flow of recyclable materials such as paper, plastic, metal, and glass. Statistical analyses and graphical representations revealed key trends, with plastic identified as the most dominant waste type, surpassing paper and metal in volume. These findings underscore the urgent need for targeted waste management strategies that focus on the most prevalent materials. The data gathered can guide policymakers, waste management professionals, and environmental advocates in optimizing recycling efforts, reducing landfill dependency, and promoting sustainable urban waste practices.

In terms of enhancing the productivity and efficiency of manual sorting in the scrap recycling industry, the following recommendations are proposed:

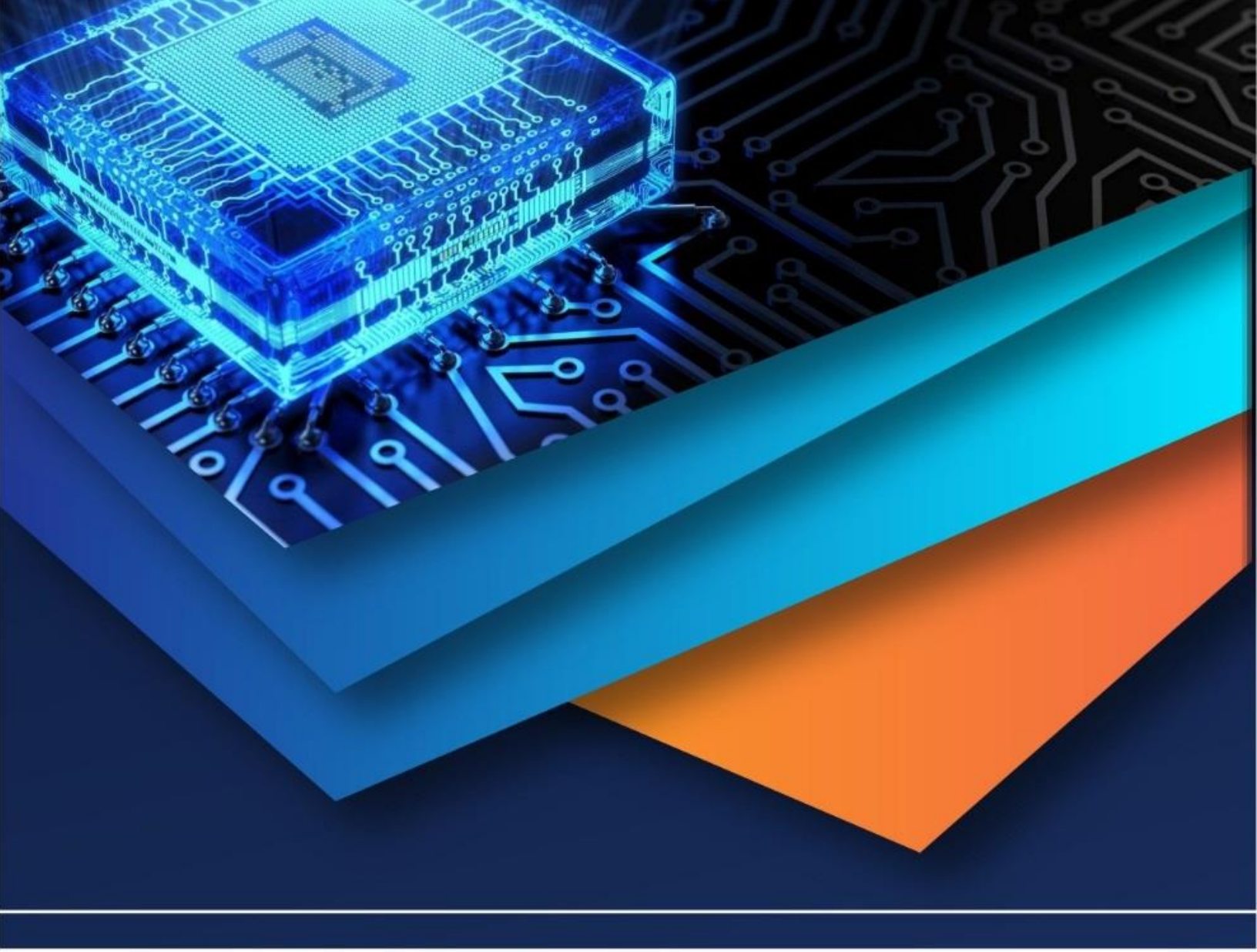
1) Task Optimization: Streamline task distribution and implement structured sorting protocols to improve workflow.
2) Employee Training: Provide continuous training and performance assessments to ensure workers are skilled in identifying and sorting materials effectively.
3) Material Standardization: Address challenges related to material inconsistency and introduce standardized procedures to improve accuracy and reduce waste.
4) Adoption of Technology: Integrate automation and real-time monitoring systems to support manual efforts, improve efficiency, and increase the recovery of valuable resources.

By implementing these recommendations, scrap recycling facilities can significantly boost their operational effectiveness, contribute to environmental sustainability, and expand the impact of recycling initiatives in the coming years. These measures serve as a strategic roadmap for enhancing manual sorting processes and advancing the overall goals of sustainable waste management.

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