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# Design and Manufacturing of Semi-automatic Garbage cart

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**Abstract** - Efficient waste management in urban areas is essential for public health and environmental sustainability. This paper presents the design and development of a Semi-Automatic Garbage Cart aimed at reducing the physical strain on workers while improving the efficiency of waste collection. The cart utilizes an electric motor powered by a lithium-ion battery for its semi-automatic functionality. Lightweight polypropylene (PP) sheets were selected for the cart, ensuring durability and ease of handling. The design incorporates an ergonomic structure for improved maneuverability in narrow spaces. Field trials showed that the semi-automatic system reduced collection time by 40% compared to manual carts, while also decreasing the physical effort required from workers. This study demonstrates the potential of semi-automation in enhancing urban waste management, offering a practical and cost-effective solution that can be easily integrated into existing sanitation systems.

***Keywords:*** Semi-Automatic Garbage Cart, Electric Motor, Lithium-Ion Battery, Polypropylene Sheets, Waste Management, Urban Sanitation.

## 1.INTRODUCTION

Waste management is a key aspect of maintaining public health and environmental sustainability, especially in rapidly growing urban areas. Traditional hand-pulled carts, commonly used by the Pune Municipal Corporation (PMC), depend heavily on human effort. These carts are widely deployed, with PMC utilizing between 3,000 and 5,000 carts depending on the city's needs. Waste pickers typically work in pairs, covering 250-400 households each for door-to-door waste collection. While PMC has successfully achieved nearly 75% household coverage for door-to-door services, only about 50-60% of households segregate their waste into wet and dry categories, which affects the overall efficiency of the waste collection process.

Despite the extensive use of manual carts, these systems remain inefficient and physically demanding for workers. Workers are exposed to health risks due to the physical strain of handling heavy loads and navigating narrow streets. There is, therefore, an urgent need for solutions that can reduce the physical burden on workers while improving the overall speed and efficiency of waste collection.

The semi-automatic garbage cart developed in this study aims to address these challenges by incorporating an electric motor powered by a lithium-ion battery. This design not only reduces manual effort but also improves manoeuvrability in urban spaces.

## 2. Body of Paper

### 2.1 Methodology

The methodology for the design and development of the semi-automatic garbage cart was systematically framed to address the challenges faced by sanitation workers during conventional waste collection activities. This methodical approach ensured that the solution was not only practical and ergonomic but also technologically feasible and cost-effective. The major stages involved in the project are detailed below:

#### 2.1.1 Problem Identification and Market Survey

An extensive problem identification phase was conducted to gather insights from waste collection workers, particularly those employed by municipal authorities using traditional hand-pulled carts. Surveys and interviews with workers revealed operational challenges such as excessive physical strain, long working hours, and slow collection efficiency. Difficulties in manoeuvring the carts through narrow, congested streets and health issues arising from continuous physical labour were also highlighted. This field data became the foundation for setting functional requirements in the improved design.

**Table-1. Lohagaon (Moze aali) Area Pune 411047**

| Date | Time of Start | Time of End | Total Time (Minutes) | Number of Houses | Distance Traveled (Km) | Time per House (Minutes) |
|---|---|---|---|---|---|---|
| 11/5/24 | 6 AM | 12 PM | 360 | 150-200 | 2-3 | 3 min |

**Table-2. Dhanori Area (Tingre nagar) Pune 411015**

| Date | Time of Start | Time of End | Total Time (Minutes) | Number of Houses | Distance Traveled (Km) | Time per House (Minutes) |
|---|---|---|---|---|---|---|
| 18/5/24 | 6 AM | 12 PM | 360 | 200-250 | 3-5 | 5 min |

#### 2.1.2 Requirement Specification

Based on the feedback from workers, a comprehensive specification was created, which outlined the following key objectives:

- Reduction of human physical effort through motorized assistance.
- Enhancement of travel speed between collection points.
- Structural strength for durability under heavy-duty use.
- Lightweight construction to enhance manoeuvrability.
- Cost-effectiveness for widespread municipal deployment.
- Simplicity in design to ensure ease of fabrication, maintenance, and repair.

These requirements helped guide the design process to ensure that the end product effectively addressed the root problems faced by the users.

### 2.1.3 Conceptual Design

Multiple conceptual designs were brainstormed and evaluated based on ease of use, ergonomics, safety, strength, weight, manufacturability, and cost. A key focus was integrating an electric assist mechanism to reduce pushing effort. Several CAD models were created to simulate real-world performance, optimizing parameters like dimensions, wheel placement, and motor specifications before fabrication.

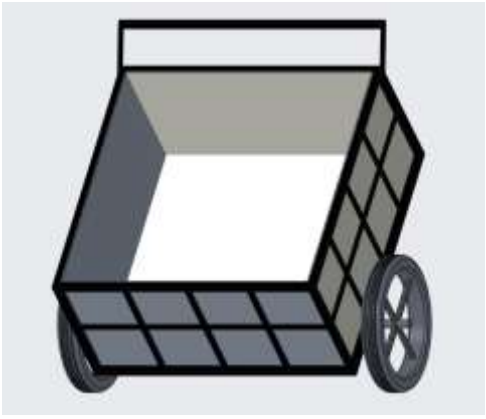

Figure 1- CAD Modal of Cart

### 2.1.4 Material Selection

Material selection was a critical aspect to ensure the desired balance between strength, weight, and affordability. The selected materials include:

- **Mild Steel (MS)** for the main structural frame, offering strength and rigidity.
- **Polypropylene Sheets** for covering and panelling, offering a high strength-to-weight ratio, corrosion resistance, and improved manoeuvrability.
- **Electric Motor** with an inbuilt gearbox to provide the required torque for efficient low-speed operation under heavy loads.
- **Pneumatic Tires** to ensure smoother movement over uneven surfaces typically found on urban waste collection routes.

### 2.1.5 Fabrication

The fabrication phase began with the cutting, bending, and welding of the mild steel frame according to finalized CAD dimensions. Polypropylene sheets were cut and fitted for the base and vertical side panels. The motor was carefully installed and aligned with the wheels to ensure effective propulsion while maintaining manual control. All mechanical and electrical systems were integrated systematically to ensure user-friendliness, with additional safety measures like a stable center of gravity and protected wiring layouts incorporated.

### 2.1.6 Testing and Evaluation

Rigorous testing was conducted under real-world conditions to evaluate key parameters such as ease of operation, speed, and effort required for navigating designated routes. The cart's load-carrying capacity, stability under full load, frame durability, and battery performance were thoroughly assessed. Worker feedback on usability, comfort, and overall satisfaction was also collected. Testing across various terrains, including narrow streets, open roads, and inclines, ensured the cart's robustness and adaptability. Minor modifications were made based on feedback to optimize its performance.

### 2.1.7 Finalization

Upon successful testing, the final prototype was documented thoroughly, detailing material specifications, electrical configurations, assembly instructions, and maintenance guidelines. Recommendations for potential improvements, design enhancements, and scaling for municipal use were also recorded.

Figure 2- Fully Developed Semi-Automatic Garbage Cart.

### 2.2 Design Specifications

The **semi-automatic garbage cart** is designed to optimize waste collection while reducing physical strain and enhancing operational efficiency. Key specifications are outlined as follows:

### 2.2.1 Motor and Power System

For moving a load of 250 kg at a walking speed of 5 km/h, the required force is approximately 73.575 N, corresponding to a power requirement of 102.2 W. A 250W, 24V electric motor with an inbuilt gearbox was

selected for the task. This motor operates at 40% of its full capacity, providing a safety margin of 2.45 times the required power. This ensures reliable performance, reduces strain, and enhances system longevity. If a motor without an inbuilt gearbox were selected, it would have been necessary to integrate an external gearbox system, which would add complexity and costs.

### 2.3.1 Time Distribution Analysis

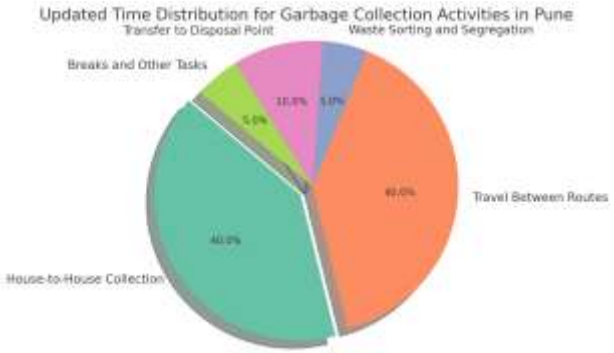


Figure 3: Distribution of Time Spent on Various Garbage Collection Tasks

A field survey and time analysis of garbage cart workers' daily activities revealed that a significant portion of the workday is spent on House-to-House Collection and Travel Between Routes, each accounting for 40% of the total time. Waste Sorting and Segregation contribute only 5% of the work time, while Transfer to Disposal Points and Breaks account for 10% and 5%, respectively. This analysis highlights the opportunity to optimize waste collection routes and introduce semi-automated systems to reduce manual effort, improve overall productivity, and enhance the efficiency of municipal waste collection services.

## 2.4. PERFORMANCE ANALYSIS

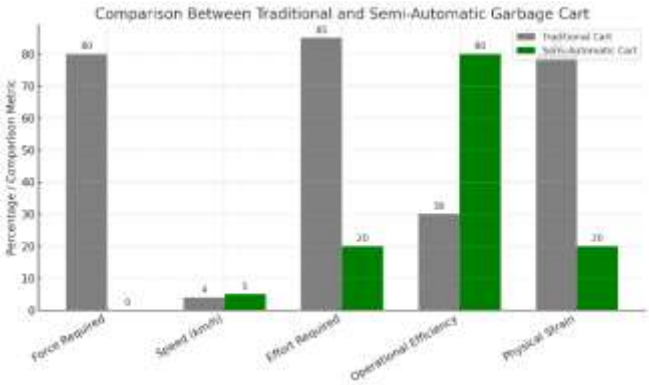


Figure 4: Comparison Between Traditional and Semi-Automatic Garbage Cart

## 3. CONCLUSIONS

The semi-automatic garbage cart design significantly reduces the physical effort of waste collection workers by integrating an electric motor for assistance. The cart's lightweight materials and ergonomic features enhance maneuverability, while its structural integrity ensures durability. Extensive testing confirmed its efficiency in real-world conditions, improving the overall productivity and reducing worker strain. The design is cost-effective, easy to fabricate, and scalable for municipal use. With the successful prototype, future improvements and widespread implementation can further optimize waste management processes.

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## REFERENCES

1. P. Mishra and T. Joshi, "Optimization of Semi-Automatic Waste Collection Vehicle," *Journal of Mechanical and Civil Engineering*, vol. 4, no. 1, pp. 15-20 (2020).
2. S. Gupta, "Smart Waste Management Systems: A Semi-Automated Approach," *International Journal of Environmental Science and Development*, vol. 10, no. 1, pp. 45-50 (2019).
3. A. Sharma, "Automation in Garbage Collection Using IoT," *Journal of Environmental Engineering and Technology*, vol. 8, no. 2, pp. 89-96 (2018).
4. M. A. Khan, "Semi-Automatic Garbage Cart Using Embedded Systems," *International Journal of Emerging Technologies in Engineering Research*, vol. 6, no. 5, pp. 22-29 (2018).
5. J. Patel and R. Singh, "Development of a Low-Cost Semi-Automatic Garbage Collecting Vehicle," *Journal of Innovative Research in Science, Engineering and Technology*, vol. 7, no. 3, pp. 312-318 (2017).