CleanMitra: Smart waste management system

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ABSTRACT

The **Smart Waste Management System** is an advanced application designed to optimize waste collection and tracking using a structured digital approach. The system integrates **MongoDB** for efficient data storage and retrieval, ensuring a seamless experience for users, administrators, and waste management personnel. The primary goal of this project is to streamline the waste collection process, enable real-time issue reporting, and provide secure user authentication with role-based access control.

This system allows users to **report waste-related issues** by submitting descriptions and images. These reports are stored in MongoDB along with an optional photo, which is handled through **GridFS**, a file storage system within MongoDB. The database securely manages user credentials, issues, and associated images. Additionally, the system supports **status tracking**, enabling waste management authorities to update issue resolutions and attach proof images.

The project is implemented using **JavaFX** for its user interface, ensuring an interactive and user-friendly experience. The backend efficiently handles **user authentication, issue tracking, and data retrieval** while maintaining a persistent database connection. The **MongoDBUtil** class plays a key role in managing database operations, including inserting and retrieving user details, handling waste reports, and managing images in GridFS.

A robust **role-based access control mechanism** ensures that only authorized users can access specific functionalities. This enhances security and accountability within the system. Additionally, an automated cleanup mechanism allows administrators to delete old records along with associated images, ensuring efficient database management.

Overall, this Smart Waste Management System provides a **reliable, scalable, and efficient solution** for waste tracking and issue resolution, promoting a cleaner environment and more effective waste management strategies.

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INTRODUCTION

Waste management is now a major problem faced by urban areas around the world. As cities continue to grow and populations expand, the volume of waste generated has risen significantly. Proper waste management is crucial not only to maintain the cleanliness and health of a community but also to ensure sustainable environmental practices. However, traditional methods of waste collection and disposal are often inefficient, leading to uncollected waste, overflowing bins, and delayed response times. This inefficiency can result in unsanitary conditions and a negative impact on the environment.

In response to this growing issue, technology can provide a more efficient and organized solution. The **Smart Waste Management System** is designed to tackle these challenges by offering a digital platform that integrates real-time waste tracking, issue reporting, and role-based management. The system allows users to report waste-related problems easily through an intuitive interface, which automatically stores these reports and tracks their resolution.

At the core of this system is **MongoDB**, a flexible and scalable database that handles user data, issue reports, and image storage. The integration of **GridFS** ensures that waste-related issues, including images, are efficiently managed and stored in the database. This real-time reporting system enables waste management teams to prioritize and address issues more effectively.

The platform is built using **JavaFX** for its user interface, offering an interactive and modern design that simplifies the reporting process for users. The **MongoDBUtil** class is responsible for managing all database operations, ensuring smooth interaction between the user interface and the backend system.

By providing a **centralized, automated solution**, the Smart Waste Management System enhances the speed and accuracy of waste collection and tracking, ultimately contributing to a cleaner and more sustainable environment. Through this innovative system, both residents and waste management authorities can work together to create a more efficient and accountable waste management process.

OBJECTIVE

1. **Efficient Waste Collection** – Ensure timely and systematic waste collection by tracking waste levels and optimizing collection routes.

2. **User-Friendly Interface** – Provide an easy-to-use platform where users can report issues, track waste collection, and access important updates.

3. **Role-Based Access Control** – Allow different user roles (Admin, Driver, and User) with specific permissions to manage waste-related tasks efficiently.

4. **Real-Time Monitoring** – Enable live tracking of waste collection activities to improve management and reduce delays.

5. **Data-Driven Decision Making** – Store and analyze data in MongoDB to improve waste management strategies and enhance operational efficiency.

LITERATURE REVIEW

[1] GoGarbage and Comparison with Our Smart Waste Management System

Overview of GoGarbage

GoGarbage is a technology-driven waste management platform developed by Deesoo Innovations Private Limited. It provides a **Software as a Service (SaaS)** model to simplify waste collection, segregation, and recycling. The platform allows users to schedule waste pickups, offers fair pricing for scrap materials, and enables cashless transactions for convenience. Additionally, it provides doorstep waste collection and real-time tracking of pickup requests.

GoGarbage aims to promote responsible waste disposal by encouraging users to recycle and segregate waste effectively. It also creates job opportunities for unskilled workers, such as ragpickers and cleaners, by integrating them into formal waste management processes. The platform offers a **mobile application** for easy waste pickup requests and monitoring.

Drawbacks of GoGarbage

1. No Real-Time Waste Monitoring

- GoGarbage's Limitation: It does not track waste levels in real time, leading to inefficient collection.

2. Lack of Role-Based Access Control

- GoGarbage's Limitation: No distinction between Admins, Drivers, and Users, leading to management inefficiencies.

3. Dependent on Manual Pickup Requests

- GoGarbage's Limitation: Users must manually schedule pickups, which can cause delays.

4. No Integrated Issue Reporting Feature

-   GoGarbage's Limitation*:* Users cannot report missed pickups or overflowing bins through the platform.

[2] Aakri: online waste management platform

Aakri is an online waste management platform that focuses on **scrap collection, recycling, and responsible waste disposal**. It provides waste pickup services for residential households, businesses, and industries. The platform aims to create an eco-friendly waste management system by offering a **marketplace** for scrap buyers and sellers, promoting recycling, and ensuring proper disposal of waste materials.

Aakri also specializes in **biomedical waste management**, handling items like expired medicines, diapers, sanitary napkins, and lab waste as per government regulations. Through its mobile and online services, Aakri connects users with waste collectors, allowing them to schedule pickups and receive payments for recyclable materials.

While Aakri provides a structured waste collection system, it has certain **limitations** that our **Smart Waste Management System** aims to overcome.

Key Features of Aakri

1. **Residential Scrap Removal** – Users can schedule scrap pickups, and Aakri provides doorstep collection with instant payment.

2. **Domestic Biomedical Waste Removal** – The platform ensures safe disposal of biomedical waste, following proper waste management guidelines.

3. **Commercial Scrap Removal** – Businesses can request scrap removal for unused materials, improving workspace efficiency.

4. **Recycling Marketplace** – Aakri connects buyers and sellers of scrap materials, promoting waste recycling and reuse.

Drawbacks of Aakri and How Our System is Better

1. **Limited Real-Time Waste Monitoring**

    o   Aakri's Limitation*:* Does not track waste levels in real time, leading to inefficiencies in collection.

2. **Absence of Role-Based Access Control**

    o   Aakri's Limitation*:* No distinction between Admins, Drivers, and Users, affecting management efficiency.

3. **Manual Scheduling of Pickups**

> o   Aakri's Limitation*:* Users must manually schedule pickups, which can cause delays.

4. **No Integrated Issue Reporting System**

> o   Aakri's Limitation*:* Users cannot report missed pickups or overflowing bins within the platform.

[3] E-Waste Management System

Overview

The Central Pollution Control Board's E-Waste Management System is a centralized digital platform designed to track, manage, and regulate the lifecycle of e-waste across India. It connects producers, dismantlers, recyclers, and authorities in real-time to ensure environmentally sound processing of electronic waste, aligned with Extended Producer Responsibility (EPR) regulations.

Key Features

- **Digital EPR Authorization**: Producers must register and obtain EPR certificates online.

- **E-Waste Tracking**: Real-time tracking of e-waste from generation to final disposal.

- **Stakeholder Integration**: Connects producers, recyclers, refurbishers, and the CPCB.

- **Data Analytics**: Offers dashboards for monitoring e-waste flow and compliance.

- **Automated Verification**: Validates certificates and documents digitally.

- **Eco-Friendly Compliance**: Promotes safe recycling practices and environmental standards.

Drawbacks

- **Limited Public Awareness**: Most general users are unaware of the platform or how to use it.

- **Complex Interface**: Not very user-friendly for smaller recyclers or individual consumers.

- **Technical Glitches**: Occasional slowdowns and system errors may affect certificate uploads.

- **Centralized Only**: Heavily reliant on producers and formal recyclers, ignoring informal sectors.

[4] Sensoneo: Smart Waste Management Software System

Overview

Sensoneo's Smart Waste Management System is an innovative solution that uses **IoT-enabled sensors**, **data analytics**, and **real-time monitoring** to optimize waste collection. Designed for cities, businesses, and waste collection companies, the system automates the waste management lifecycle, aiming to reduce operational costs, environmental impact, and traffic congestion caused by inefficient collection routes.

Key Features

- **Smart Sensors**: Ultrasonic sensors placed inside bins detect fill levels and transmit data over secure networks.

- **Dynamic Collection Routes**: Uses AI and historical data to generate optimal waste collection routes.

- **Real-time Monitoring**: Tracks fill levels, collection status, and fleet movement through a central dashboard.

- **Alerts & Notifications**: Automatically sends notifications when bins are nearly full or if abnormalities are detected.

- **Scalability**: Can be integrated into small communities or large metropolitan cities.

- **Environmental Focus**: Contributes to CO_2 reduction by minimizing unnecessary trips and improving waste sorting.

Drawbacks

- **Initial Cost**: Implementation can be expensive due to sensor deployment and setup.

- **Technical Dependency**: Requires stable internet connectivity and GPS for optimal operation.

- **Maintenance Needs**: Sensors and tracking systems require regular upkeep.

- **Integration Challenges**: May face issues while integrating with existing municipal infrastructure or legacy systems.

EXISTING SYSTEM

1. **Scheduled Waste Collection**
   Most systems allow users to manually schedule waste pickups through mobile or web platforms, providing doorstep collection for residential, commercial, and industrial users.

2. **Support for Recycling and Disposal**
   These systems promote recycling by offering platforms for scrap selling and ensure safe disposal of materials, including biomedical and electronic waste, in compliance with regulations.

3. **Digital Convenience and Worker Integration**
   Features like digital payments, mobile tracking, and integration of unskilled labor (e.g., ragpickers) into the formal sector help streamline operations and expand employment opportunities.

4. **Technology-Driven Optimizations**
   Some advanced platforms utilize IoT sensors and route optimization tools to improve collection efficiency, monitor bin fill levels, and reduce environmental impact.

DISADVANTAGES IN EXISTING SYSTEMS

1. Lack of Role-Based Access

Most systems do not provide separate dashboards or access control for different users like admins, drivers, or residents.

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2. No User Feedback or Complaint Option

There is often no simple way for users to report issues like missed pickups or damaged bins.

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3. No Real-Time Tracking

Many platforms don't show live updates of bin status or collection activities, which can lead to delays and overflows.

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4. Missing OTP or Secure Login Features

Some platforms lack basic security features like OTP verification during sign-up or login.

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5. Complicated or Outdated Interfaces

User interfaces are often not intuitive or attractive, making them hard to use for the general public.

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6. Not Designed for Household Waste

A few systems focus mainly on industrial or large-scale municipal waste, ignoring needs of individual households.

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7. No Notifications or Alerts

Most systems do not send SMS or email notifications to keep users updated on their requests or waste collection schedules.

PROPOSED IDEA

The proposed Smart Waste Management System is designed to modernize and simplify waste collection using technology-driven solutions. It addresses the common challenges faced in current systems and offers a user-friendly platform for effective waste handling in both urban and household settings.

This system introduces a **role-based platform** where users, drivers, and administrators each have their own login and dashboard. By using smart sensors and real-time monitoring, the system can track bin fill levels, optimize routes for collection, and minimize unnecessary pickups.

To ensure security and prevent unauthorized access, the platform supports **OTP-based email verification** during login and registration. In addition, users can easily **report issues** like missed pickups, full bins, or broken containers directly through the interface, which is stored in a MongoDB database for quick action by the admin.

The system also focuses on simplicity and ease of use. Built with a **modern, attractive UI using JavaFX**, it ensures that users from all backgrounds can navigate it without confusion. It supports **real-time SMS alerts** using services like Twilio, so users get notified about the status of their requests or waste collection schedules.

Most importantly, this solution is **not limited to large municipalities**—it is built to serve individual homes, small communities, and organizations, making it a **scalable** and **inclusive** platform.

Key Features

1. Role-Based Access Control

The system supports three main user roles:

- **Admin**: Manages users, drivers, waste reports, and system analytics.

- **Driver**: Views assigned pickup tasks, updates collection status.

- **User**: Reports issues, tracks bin status, and manages profile.

Each role gets a **separate dashboard** for a personalized experience.

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2. Real-Time Bin Monitoring (IoT Ready)

The system is designed to work with **smart sensors** that detect the **fill level of bins**. This data can be used to:

- Track overflow situations,

- Plan pickups more efficiently,

- Avoid unnecessary collections.

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3. Live Status Dashboard

The Admin dashboard shows:

- Number of reported issues,

- Total users and drivers,

- System activities and alerts.

This helps in taking fast decisions and tracking real-time performance.

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4. OTP-Based Email Verification

To make login secure, the system sends a **One-Time Password (OTP)** to the user's email. This prevents fake registrations and ensures verified access for all users.

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5. Issue Reporting System

Users can easily report:

- Missed pickups,

- Overflowing bins,

- Broken containers.

All reports are stored in **MongoDB**, and the admin can update their status (e.g., pending, resolved).

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6. SMS Notification (Twilio Integration)

When a user submits a request or a pickup is completed, the system sends an **SMS alert** to keep users updated. This improves communication and trust.

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7. Modern and Simple UI (JavaFX)

The platform has a **clean and user-friendly interface**:

- Built using **JavaFX** for smooth interaction.

- Easy to navigate, even for first-time users.

- Responsive and designed with accessibility in mind.

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8. MongoDB Integration

All data (users, drivers, issues, etc.) is stored in a **MongoDB database**, ensuring:

- Fast access,

- Easy scalability,

- Efficient data handling and querying.

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9. Household Waste Support

Unlike industrial-focused platforms, this system is designed to serve:

- Individual homes,

- Small communities,

- Apartments and societies.

This makes it ideal for **both urban and residential use**.

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10. Temporary File Storage (GridFS Ready)

The system can be extended to support file storage (like issue images or receipts) using **GridFS**, a part of MongoDB, to store large files efficiently.

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11. Status Updates and Progress Tracking

Admins can update the progress of each complaint or report. Users can track the status of their submissions through their dashboard.

SYSTEM ARCHITECTURE

The Smart Waste Management System is a desktop-based application developed using JavaFX for the user interface and Java as the core programming language. MongoDB is used as the backend database to store user details, reported issues, and task statuses. The system provides a role-based interface for general users, admins, and drivers, ensuring efficient waste reporting, task assignment, and resolution tracking.
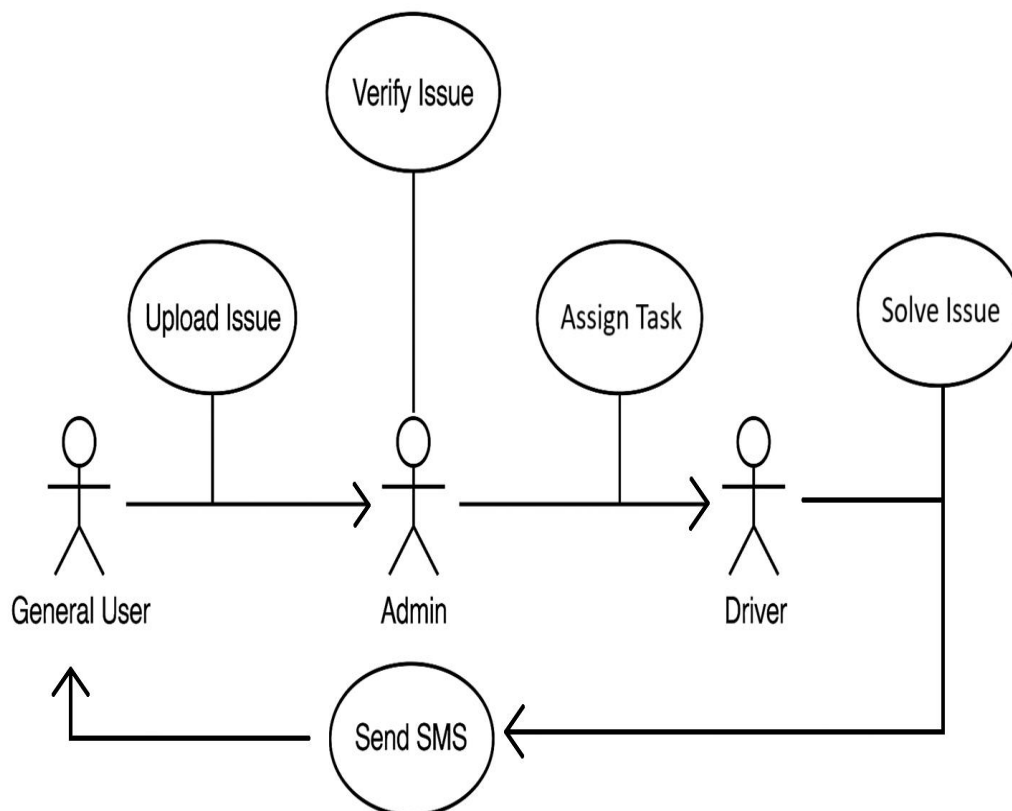

Fig 1: Architecture Diagram

General User

1. The General User reports waste-related issues through the system by uploading relevant information.

2. Once the issue is submitted, the user awaits confirmation and resolution updates.

3. Upon resolution, the user receives an SMS notification confirming the issue has been addressed.

Admin

1. The Admin reviews each uploaded issue and verifies its authenticity and details.

2. After verification, the Admin assigns the task to an available driver for resolution.

3. The Admin ensures timely communication with both users and drivers through automated SMS alerts.

Driver

1. The Driver receives assigned waste issues from the admin to handle and resolve them.

2. After resolving the issue, the driver updates the system to reflect the task completion.

3. The driver's actions help maintain cleanliness and responsiveness within the waste management cycle.

RESULT AND DISCUSSION

- The Smart Waste Management System, **CleanMitra**, worked successfully as planned. It allowed three types of users—Admin, Driver, and User—to log in and use the system based on their roles. Users could report waste issues, and the system saved all details, including images, in **MongoDB** using **GridFS**. Admins could manage users, assign tasks to drivers, and track progress. Drivers could update the status of tasks in real-time.
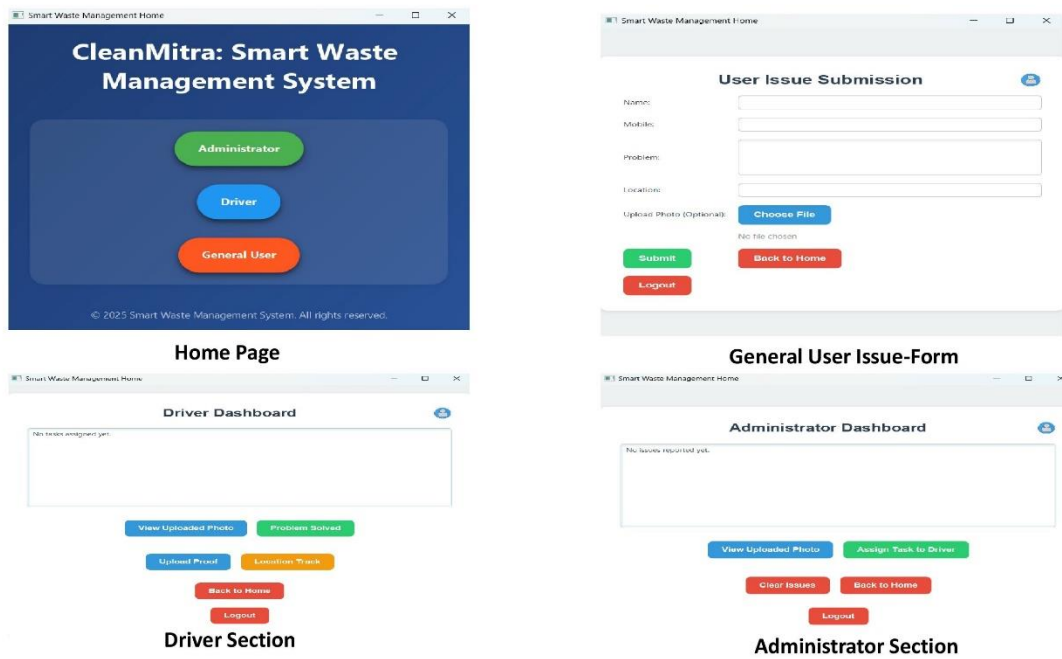
Home Page

General User Issue-Form

Driver Section

Administrator Section

Fig 2: Result Snapshot

Administrator Login/Signup

Driver Login/Signup
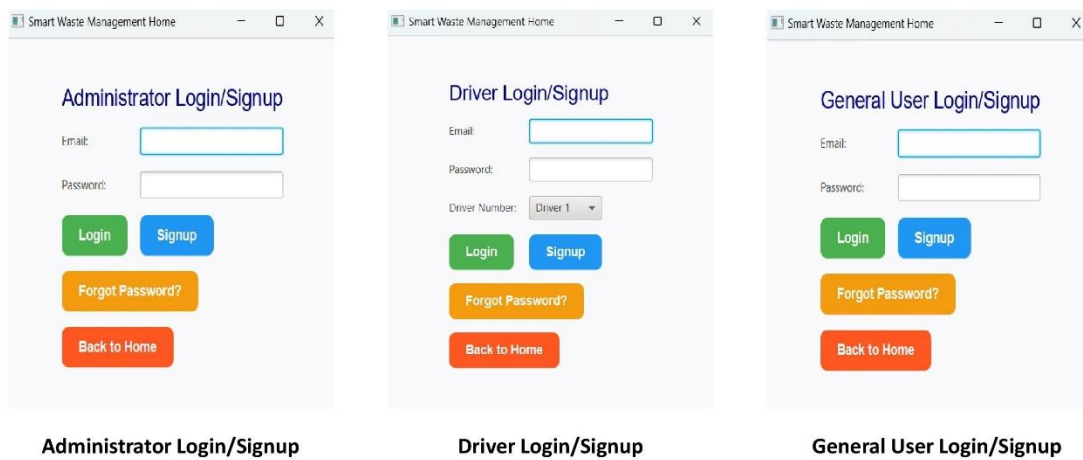
General User Login/Signup

Fig 2.1: Result Snapshot

- The user interface built with **JavaFX** was simple and easy to use. MongoDB ensured that all data was stored safely and could be accessed anytime. The system also supported smooth interaction between different users.

- CleanMitra showed that smart technology can help cities manage waste better. It is a strong base for adding more features like chatbots, SMS alerts, or GPS tracking in the future. Overall, it is a useful and reliable system for smart waste management.

CONCLUSION

CleanMitra proves that technology can make city life cleaner, easier, and smarter. By bringing together real-time issue reporting, role-based access, and reliable data storage, the system makes waste management faster and more efficient. Admins can track problems, assign drivers, and see progress clearly. Users can quickly report issues with photos, and drivers can update tasks instantly—all from one easy-to-use platform.

Using MongoDB and JavaFX, CleanMitra ensures smooth performance and safe data handling, even after the app is closed. It also allows future upgrades like chatbots, GPS tracking, SMS/email alerts, and mobile app integration.

What makes CleanMitra special is its ability to solve real-world problems with a smart, modern approach. It's not just a project—it's a vision for cleaner cities and better living. With further development, CleanMitra can become a full-scale solution for smart cities across the country.

This system is a big step toward a cleaner and smarter future. It reflects how thoughtful design and technology can create meaningful change in everyday life.

REFERENCE:

[1] GoGarbage: GOGARBAGE - Sell the waste online | Free Garbage Pickup | door step waste collector | Online Kabadiwala | Online Garbage Collector | Waste Collections App

[2] Aakri: Aakri | On-Demand Waste Management App

[3] E-Waste Management System: E-Waste Management System

[4] Sensoneo: Smart Waste Management Software System (WMS) | SENSONEO