International Journal of Scientific Research & Engineering Trends
Volume 11, Issue 2, Mar-Apr-2025, ISSN (Online): 2395-566X

A Smart Reverse Vending Machine for Plastic Bottles

Assistant Professor V. Srinivas Rao, Narla Sai Kiran, Rajarapu Pavan Jagadeesh, Sanagapalli Madhav, Sarikonda Mahendra Sai, Sariki Appalanaidu
Mansarovar Global University, Bhopal

Abstract- The exponential rise in plastic waste, particularly from single-use PET bottles, presents a critical challenge to environmental sustainability. Conventional recycling approaches are often hindered by inconvenient manual processes, limiting public engagement. To counter this, the proposed Smart Reverse Vending Machine (RVM) offers an automated, user-friendly solution for the collection and preliminary sorting of plastic bottles. The system employs an Arduino Uno microcontroller, an IR sensor, and a load cell with HX711 amplifier to detect, validate, and weigh deposited bottles. In exchange, users receive immediate incentives such as coins, fostering responsible waste disposal habits. Designed with affordability and scalability in mind, this compact system is ideal for installation in high-traffic areas like malls, transport hubs, and educational campuses. The initiative aims to enhance recycling participation through real-time rewards and minimal operational complexity. Potential future enhancements include IoT connectivity, AI-based recognition, and digital rewards, positioning the system as a smart and sustainable waste management solution.

Index Terms- Smart Reverse Vending Machine, Plastic Bottle Recycling, Arduino Uno, Load Cell, HX711, IR Sensor, Waste Management, Automated Recycling.

I. INTRODUCTION

Plastic pollution, particularly from single-use bottles, has emerged as a pressing global environmental issue. Despite growing awareness and recycling initiatives, improper disposal and inadequate waste management continue to hinder efforts toward sustainability. Traditional recycling systems are often centralized and inconvenient, which discourages consistent public participation.

To address this challenge, technological solutions such as Smart Reverse Vending Machines (RVMs) have gained attention. These machines automate the collection of recyclable plastic items, streamline sorting, and provide incentives to users, thereby promoting responsible disposal behavior. By integrating cost- effective components like Arduino Uno, IR sensors, and load cells, the proposed RVM offers a simple yet efficient method for encouraging public engagement in recycling.

This project focuses on developing a compact, user- friendly, and reward-driven smart RVM that can be deployed in public locations such as malls, railway stations, schools, and residential complexes. It operates on the principle of "Cash from Trash," where users are rewarded in real time for depositing plastic bottles. The system aims to foster sustainable habits by combining automation, embedded electronics, and potential for IoT integration.

II. METHODOLOGY

Overview of the System
The Smart Reverse Vending Machine (RVM) is created to automatically collect and process plastic bottles. It is built using affordable electronic parts and controlled by an Arduino Uno. The main goal is to detect when a bottle is inserted, check its weight, and give a reward if it meets the set conditions. This system is designed to be simple, low-cost, and suitable for installation in busy public places.

How the Bottle is Detected
When a user puts a bottle into the machine, an infrared (IR) sensor detects its presence. This sensor works by sending out invisible light and checking for changes when the bottle enters the slot. This action tells the machine to begin the next step checking the weight of the bottle.

Weighing the Bottle
Once the bottle is inside, it is placed on a load cell, which a sensor is used to measure weight. This sensor is connected to a small amplifier called the HX711. Together, they send accurate weight information to the Arduino. If the bottle weighs enough usually more than 12 grams the machine will consider it a valid item for a reward.

Control Using Arduino
The brain of the machine is the Arduino Uno microcontroller. It reads the signals from the IR sensor and the weight sensor.

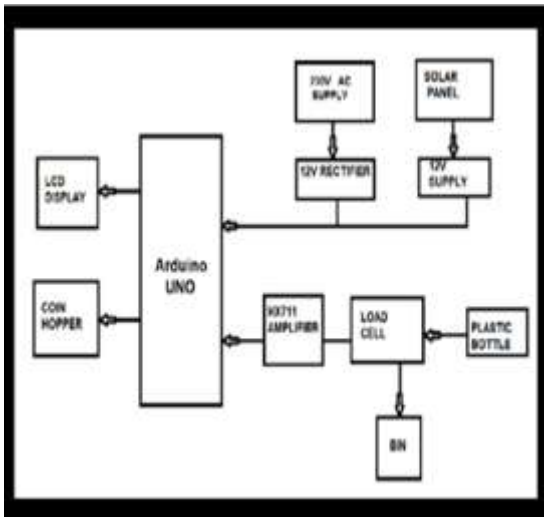
Based on this information, it decides whether or not to give a reward. If the bottle passes the check, the Arduino activates the part of the machine that gives a coin. If not, it rejects the bottle.

Giving the Reward
When the bottle meets the requirements, the machine gives a reward usually a coin. This is done using a coin hopper or a simple mechanism that drops a coin into a tray. This reward system motivates people to recycle plastic bottles by giving them something in return.

User Instructions and Display
To help users understand what to do, the machine has a display screen (LCD). It shows messages such as "Insert Bottle," "Processing," or "Reward Given." This makes it easy for anyone to use the machine without needing help.

Power Supply
The machine runs on a 12-volt power supply. It can be connected to a plug or powered by solar energy. This makes it useful in places without a constant electricity supply and supports eco-friendly energy use.

Easy to Upgrade
The system is designed in a way that it can be improved in the future. Extra features like connecting to the internet, keeping track of users with RFID cards, or giving digital rewards through mobile apps can be added easily. This makes the machine ready for future needs and wider use.



Block Diagram

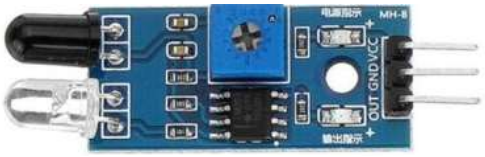
Flow Chart

Technologies Used
Hardware Technologies Used
Arduino Uno
The Arduino Uno is the main controller of the system. It reads signals from the sensors, processes the data, and controls other parts like the coin dispenser and display. It is affordable, easy to program, and suitable for small automation projects like this one.

Node MCU (ESP8266)
The Node MCU is a Wi-Fi-enabled microcontroller that can send and receive data over the internet. In this project, it is used to update bottle collection data online or to notify the system administrator when the bin is full. It also makes future IoT features possible.

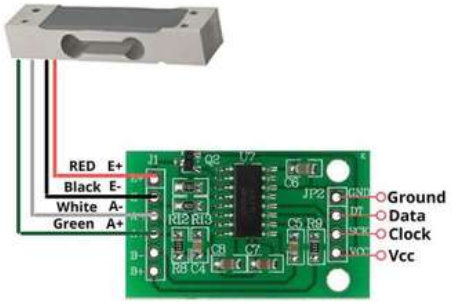
IR (Infrared) Sensor

The IR sensor detects when a bottle is inserted into the machine. It works by sending infrared light and checking if the light is reflected back, which happens when a bottle is present. This triggers the system to begin the weighing process.



Load Cell with HX711 Module

A load cell is a device that measures weight. In this system, it checks how heavy the bottle is. The HX711 is a small amplifier that reads the weak signals from the load cell and sends accurate data to the Arduino for processing.



Ultrasonic Sensor

The ultrasonic sensor measures the distance using sound waves. In this project, it is used to check if the storage bin inside the machine is full. If the bin is nearly full, the machine can stop accepting bottles or send an alert.

LCD Display

An LCD (Liquid Crystal Display) shows messages to guide users through the process. It displays instructions like “Insert Bottle,” “Processing,” and “Reward Given,” making the machine easy to use for everyone.

Power Supply and Solar Panel

The system runs on a 12V DC power supply. In addition, a solar panel can be used to power the machine in outdoor locations, helping reduce electricity usage and support green energy.

RFID Reader

An RFID reader can be added to identify users. When users scan their RFID card, the machine can track how many bottles they recycled and store reward points. This is useful for digital reward systems in the future.

Servo Motor

A servo motor may be used to open and close the lid or to control the bottle-dropping mechanism. It is precise and controlled directly by the Arduino based on sensor inputs.

Software Technologies Used

Arduino IDE

The Arduino Integrated Development Environment (IDE) is the main software used to write and upload code to the Arduino Uno microcontroller. It supports the C and C++ programming languages. In this project, it is used to program the Arduino to read sensor inputs, process the data, and control outputs like the coin dispenser and LCD display.

Embedded C Programming

The logic of the entire system is written in Embedded C, a programming language commonly used for microcontroller-based systems. This code tells the Arduino how to read sensor data, compare bottle weights, and decide whether to give a reward.

Blynk IoT Platform

Blynk is an Internet of Things (IOT) platform that is used along with the Node MCU module. It allows the system to send data to a mobile app or cloud dashboard. For example, it can send a notification when the storage bin is full or when a certain number of bottles have been collected.

Arduino Libraries

Several built-in and external libraries are used in the Arduino code. For example

- HX711.h is used to read weight data from the load cell.
- Liquid Crystal.h is used to control the LCD display.
- Servo.h is used to operate the servo motor.
- SPI.h and MFRC522.h are used for RFID functionality.

Serial Monitor

The Arduino IDE includes a Serial Monitor that helps test and debug the code. It displays real-time data from the sensors and shows how the system is responding, making it easier to fix errors during development.

Wi-Fi Configuration(NodeMCU)

The NodeMCU is programmed to connect to Wi-Fi using simple configuration code. This allows the system to communicate with the Blynk app or send alerts online. This part of the software handles cloud connectivity and remote monitoring.

Algorithm

- Initialize the system and all connected hardware components (IR sensor, load cell, LCD, servo motor).
- Wait for user interaction monitor for an item (bottle) being inserted.
- Detect the presence of a bottle using the IR sensor.
- Once detected, activate the weighing system to measure the bottle's weight.
- Evaluate the weight:
- If the bottle weighs 12 grams or more, proceed to reward logic:
- If weight is between 10g–50g, reward with Rs. 10.
- b. If weight is between 50g–100g, reward with Rs. 20.
- If weight exceeds 100g, reward with Rs. 30.
- Trigger the servo motor to release coins accordingly.
- e. Show confirmation and reward message on the LCD display.
- 7. If the weight is below 12 grams, display a message indicating no reward is given.
- 8. Reset the system for the next bottle and repeat the process.

III. RESULTS AND DISCUSSION

The implemented SMART Reverse Vending Machine was tested in a controlled environment to evaluate its efficiency in detecting, weighing, and rewarding users for plastic bottle disposal. During the testing phase, the machine successfully identified the presence of bottles using the IR sensor and accurately measured their weight through the load cell connected to the HX711 amplifier. Bottles meeting the predefined weight thresholds triggered the reward system, which dispensed coins based on the category of weight. The LCD provided real-time feedback to users, ensuring clarity and user engagement. The reward mechanism encouraged correct usage, while the servo motor consistently dispensed coins without error. The system demonstrated high reliability and responsiveness, with minimal delay between bottle insertion and reward delivery. The modular design and low-cost components contributed to its affordability and potential scalability. While the system performed effectively under test conditions, further improvementssuch as incorporating bottle shape or material recognition and digital point systemscould enhance its accuracy and user experience. Overall, the prototype proved to be a practical, user- friendly solution for encouraging recycling in public spaces.

IV. CONCLUSION

The SMART Reverse Vending Machine designed and developed in this project offers an effective and affordable solution to tackle the growing issue of plastic bottle waste. By integrating simple electronic components such as an Arduino UNO, IR sensor, load cell, and LCD display, the system automates the process of plastic bottle collection and incentivizes users through a reward mechanism. The machine operates efficiently, accurately detecting and weighing bottles, and dispensing appropriate rewards based on predefined weight categories. Its compact design and cost- effectiveness make it suitable for deployment in public spaces such as malls, transport hubs, and educational institutions. The successful implementation demonstrates that technology can play a vital role in promoting responsible waste disposal and environmental sustainability. Future enhancements, such as IoT integration, AI-based material recognition, and digital reward systems, could further expand the functionality and impact of the system.

REFERENCES

1. Nandhini, S., et al. (2023). Design and Development of Smart Reverse Vending System for PET Bottles Collection and Recycling Using Design Thinking. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering.
2. Jain, S. S., Dhotre, S. S., & Dhawale, S. D. A Review on Reverse Vending Machine. International Research Journal of Engineering and Technology (IRJET), Volume 6, Issue 4, 2019.
3. Bari, J. A. B., & Tarun, I. M. Plastic2Fantastic: Reverse Vending Machine for Plastic Bottles. International Journal of Scientific & Technology Research, Volume 8, Issue 11, 2019.
4. Sambhi, S., & Preeti. Reverse Vending Machine for Managing Plastic Waste. International Journal of Engineering Research & Technology (IJERT), Vol. 9, Issue 5, 2020.
5. Adzharia, M. S. M., & Ahmad, A. IoT-Based Reverse Vending Machine (RVM) for Recycle Station. International Conference on Computing and Data Engineering (ICCDE), 2021.