Smart Segregation Bins for Cities Using Internet of Things (IoT)

K. Srisabarimani, R. Arthi, S. Soundarya, A. Akshaya, M. Mahitha, and Sruthi Sudheer

Abstract Waste management includes various activities like the collection of waste, treatment of waste, and other such actions which if neglected will become a threat to the environment. Among these, one such significant activity is the segregation of waste. Though people tend to use the manual segregation of waste using different colors of dustbin, the sustainability of this process does not last for a much longer time. In this paper, the first half of the operation concentrates on segregation of wastes which is performed with the help of sensors and few other components, whereas the second half of the operation involves monitoring the real time updates of the dustbin which is implemented using IoT. We have used IR sensor, Ultrasonic sensor, and capacitive sensor to sense the presence of the waste, measure the level of the waste, and identify the presence of plastics, respectively. Components like an air blower, a microcontroller, rotating disk, servo motor are used to perform the action of segregation. With the help of a cloud server system, all the data of the dustbin will be stored, and using the Wi-Fi module, these data can be monitored. Even though we tend to segregate the wastes into plastic and reusable wastes, the collection of wastes from the garbage bin will be done manually because we do not want our technology to affect the work of daily laborers and eventually lead to unemployment. Keeping all these factors in mind, we have proposed this idea which will help definitely pave a way for the betterment of the society.

Keywords Ultrasonic sensor · Air blower · Arduino Uno · The internet of things · The waste management control room

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1 Introduction

A sophisticated method of waste management has an adverse effect on human health and the environment. Almost every street in India has a minimum of one dustbin in each corner where all the waste is dumped together. Even though people throw the waste inside the dustbin, quiet later after continuous dumping of waste inside the bin, it gets overflowed which would eventually result in air pollution and many other environmental issues. The segregation of the waste is so complicated that it requires more space and time. This smart segregation bin tends to separate waste into two categories—plastic waste and reusable waste. It comprises of few sensors which will be attached to either side of the bin. With the help of the sensors and air blower, the types of wastes can be categorized. The ultrasonic sensors are also installed with which the level of wastes dumped can be determined. Every dustbin has its own ID tags which contain all the information about that particular bin. When the garbage is about to overflow, it will give an alert message to the data center of the waste management control room where the level of both sides of the bin and the temperature are being indicated, using the Internet of things (IoT) through a microcontroller which is the Arduino Uno that has stored all the details regarding the bin within it. Then necessary action to collect the garbage will be taken by tracking the location through ID tags attached to each smart bin. The SMART SEGREGATION BINS indeed makes the city smart as it has many advantages which will ultimately increase the betterment of the society.

The segregation of plastic waste and reusable waste provides a sophisticated method of waste management that has an adverse effect on human health and the environment. The project contains a few sensors which will be attached to either side of the bin through which the types of waste will be categorized. It has been found that 50% of Indian residents face the problem of improper waste collection and management. This method helps to control waste management, which will pave ways for making smart cities much more efficient and clean. It also helps to create a healthy environment by reducing health risks and hazards that affect mankind. Proper waste management helps us to improve the quality of waste as well as reduce the emission of greenhouse gases. So, when they collect the waste, they are usually retrieved for redistribution, recycling, and reusing of wastes, thereby reducing pollution and other health hazards.

By implementing this method, proper waste management can be taken into account and thus utilization of resources will also increase. The smart bin is an efficient and hygienic waste disposal and segregation system which will eventually help in waste optimization.

2 Related Works

A system has a belt that is driven by dc-motor to carry the waste to the dustbins with help of sensors [1]. The metal detectors are used to separate the metallic wastes which are collected to the separate bins. Likewise, the dry and wet wastes are also collected in separate bins. The segregation method implemented is effective and helpful to the municipality for the separation of metallic waste, dry waste, and wet waste. This segregation is carried on with the help of sensors.

A smart waste bin based on the Internet of Things (IoT) [2] and the corresponding real prototype. The detail about waste in the garbage is collected and the details are transmitted over the internet. With this, the real-time status can also be viewed using any tools available online by the citizens and checks the status of availability of bins that are around different areas of the city.

A system that claims to sort the waste into wet, metallic, and dry wastes using an automatic waste sorter and a robotic waste delivery system [3]. Right after the IR sensor detects the existence of the waste, the robotic arm collects those wastes and using AWS, the sorting process is done. With the help of sensors and a robotic arm, the results of the experiment carried out are successful.

An alert system to the user about overfull of waste and manages the system and provide fully automated smart bin [4]. It also predicts if waste is wet or dry. It is efficient and saves time, helps in waste collection and management.

A mechanical arrangement for dry waste and wet waste are separated and collected into a container [5]. The dry wastes are detected using IR sensor and wet wastes are detected using moisture sensor. The percentage of waste available in the bins are represented graphically is uploaded to the application which can be viewed by the user who have account to the application. The user can access the application by using the username and password created.

A system developed by using raspberry pi contains a blower, a conveyor, and the sensors like moisture sensor, IR sensor, and capacitive proximity sensor to separate dry and wet waste [6].

The waste is separated into metallic and non-metallic waste. The experiment analysis comprises of 3 stages, where in stage 1—the detection of metallic and non-metallic wastes observed using inductive proximity sensor. In stage 2—wet and dry wastes are observed and in stage 3—the isolation process takes place.

A system to use a parallel resonance impedance system along with few sensors in order to segregate the wastes automatically [7]. The experiment is carried out successfully and using IoT the type of waste and the quantity of waste is monitored.

A methodology that uses a capacitive sensor and inductive sensor [8]. The sensor checks the waste materials and segregates metallic and non-metallic wastes which are controlled by Raspberry pi and Think Speak web. The wastes are separated and composed in varying containers that ensures the industries that waste are segregated successfully in an effective manner and waste can be recycled. The entire process is carried on using Raspberry pi.

The system composed of ARM 7 microcontroller [9], sensors, and the IoT Technology, detects the level of dirt, once it reaches the threshold level, it sends a message to the Municipal/Government authority person with the location of that waste bins using Global Positioning System (GPS).

A container consisting of an Arduino Nano board and an ultrasonic sensor is used to sense the fullness level of the bins. The SMS alert was sent using the GSM module, which was operated using a solar panel and powered by a Lithium battery. This provides effective trash management on a small scale over various locations.

A system would be able to monitor the solid waste collection, process, and segregate dry and wet waste [11]. The waste segregator segregates the waste into three major classes: plastic, organic, and metallic using Arduino successfully.

A system to segregate the wastes into three categories—metallic, wet and dry at the disposal level itself [12]. With the help of an inductive proximity sensor, the conveyor belt and a high speed blower, the wastes are been separated automatically. The experiment is done by using household waste and the test results show positive sign in segregating the waste. The localization algorithms like Multilateration (MLAT) method, K-nearest neighbor (KNN), and Minimum Mean Square Error (MMSE) method with RSS for Wi-Fi [13]. This algorithm provides a correlation between the original data stored in the database and the location of the estimated bin with high accuracy and less error.

This approach provides a range of the network that is connected in the model by reducing traffic using LoRa and power that is consumed by the device [14], [15]. This approach discussed about low energy harvesting [16].

3 Proposed Work

The main aim of the work is to segregate the wastes into plastic and reusable automatically as shown in Fig. 1. A disk is kept at the top of the bin in which there is a slight opening in the plastic side through which the plastic waste enters the other side of the bin when the air blower is turned ON. The Capacitive sensor also senses the presence of plastic waste. Initially, the wastes are dumped into the dustbin. Sensing the presence of the object, the IR sensor turns the Air blower ON with the help of the microcontroller. According to researches, the density of plastic is comparatively less than that of reusable waste. So the air blower blows the plastic wastes to the other side of the bin. The Biodegradable waste is pushed down on the same side with the help of the servo motor, which, in turn, rotates the disk. This way both the plastic and the reusable wastes are separated. Ultrasonic sensors are used to measure the level of the waste on both sides sends an alert message when the bin is about to overflow through the microcontroller to the waste management control room where the temperature, levels of plastic waste, and the biodegradable waste of the bin is being monitored during IoT.

The necessary action to collect the garbage will be taken by tracking the location through ID tags attached to each smart bin.

In Fig. 2, to monitor the real time updates of the dustbin, we have used a cloud server system where all the data regarding the bin will be stored and using the Wi-Fi module these data can be accessed. We have created a web page where the database will be displayed. All the action is performed by IoT.

In Fig. 3, Arduino is the microcontroller for our operation. To this microcontroller, all the sensors as well as other components are attached. The IR sensor is used to sense the presence of the waste once it is thrown inside the bin. The two ultrasonic sensors kept on either side of the bin is used to measure the level of waste on both plastic and reusable side. In order to get better results, a capacitive sensor is used to detect the plastics inside the waste. To regulate the power supply from Arduino to servo motor, a motor driver is used so that the disk is made to rotate which will be helpful for reusable waste segregation.

In Fig. 4, initially, when the waste is thrown inside the bin, the presence of waste is sensed by an IR sensor. It will instruct the microcontroller which will turn on the

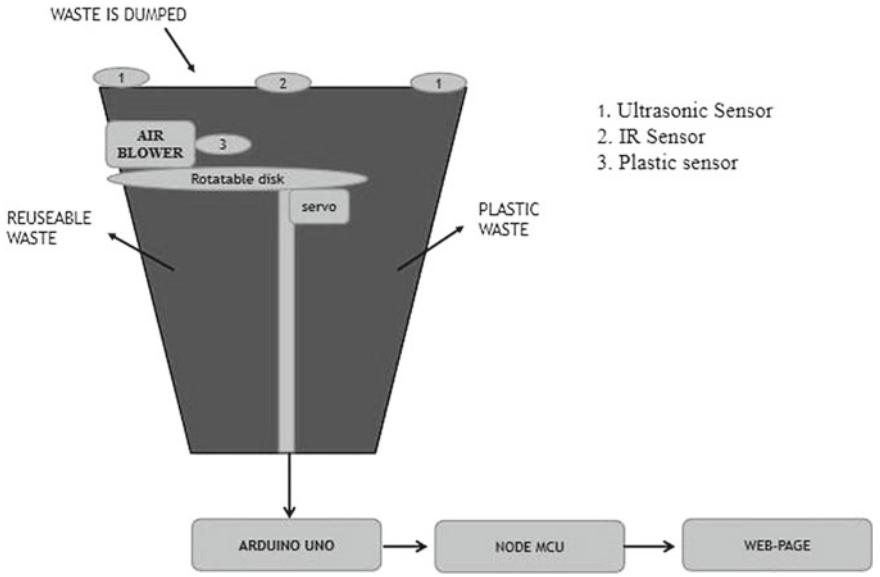
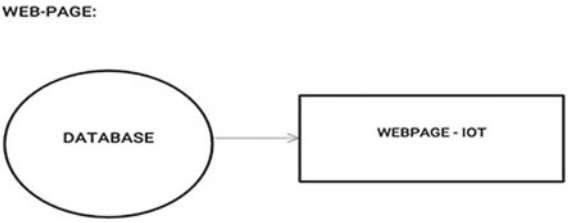


Fig. 1 The Design of smart segregation bin

Fig. 2 Web-page



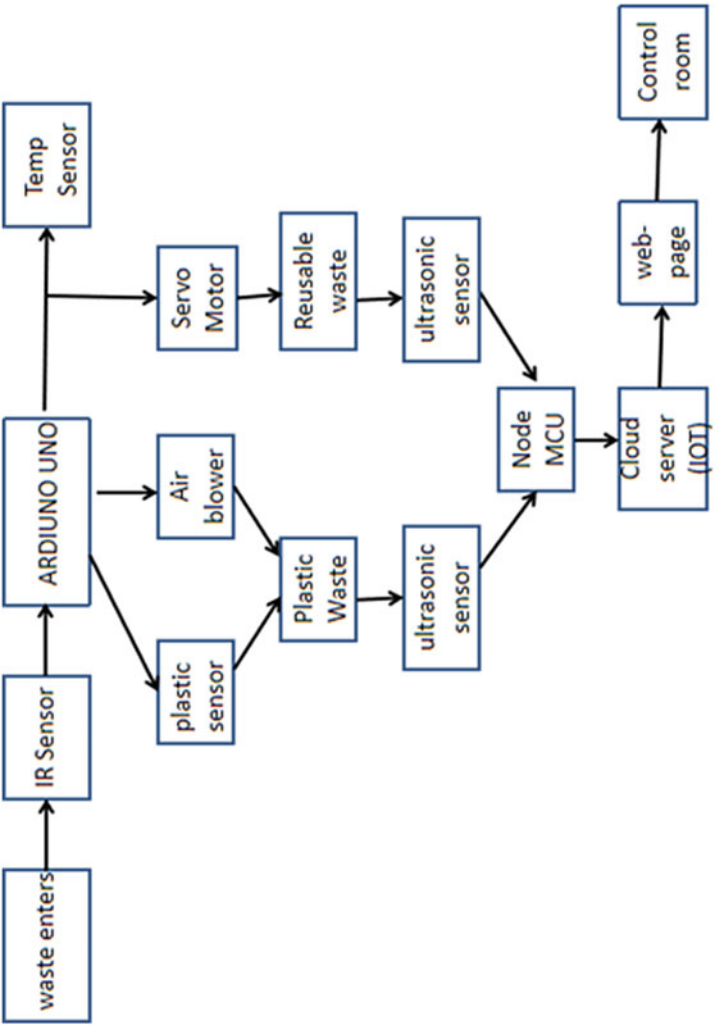


Fig. 3 The block diagram of smart segregation bins

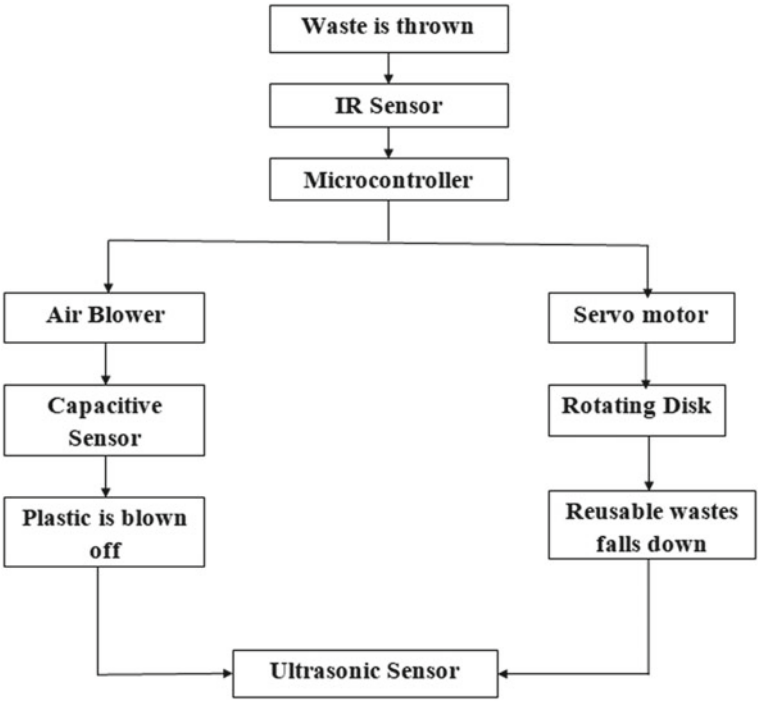


Fig. 4 The workflow of smart segregation bins

air blower which will blow off the plastic wastes to the other side of the bin since the density of plastic wastes is considerably less than that of reusable waste. According to the global survey, the density of plastic waste is found to be around 180 kg/m^3 and the density of reusable waste is around 459.35 ^{kg}/m^3 it will be easy to blow off plastic waste to the other side of the bin.

The capacitive sensor is used to sense the presence of the plastic, therefore, along with the air blower, the capacitive sensor also gives better results in segregating plastics from reusable wastes. The microcontroller will turn on the servo motor which will make the disk like structure to rotate. Once it begins to rotate, the remaining wastes which are the reusable wastes are made to push downwards so that they fall inside the bin. Likewise, the process is carried out until the waste on both sides is about to overflow.

Ultrasonic sensors are kept to measure the level of wastes on both sides. When it is about to overflow, an alert message is sent so that the waste can be collected from the garbage bin. Also, all information about the bin will be stored in the cloud server system, and using the Wi-Fi module, the real-time status of the bin can be monitored.

4 Result and Discussions

In Fig. 5, the circuit connections we have made for our project. It is clearly shown that the wires of the sensors and the rest of the other components are connected to the Arduino microcontroller. We use a relay switch to enhance the performance. Toward the downside, we have etched node MCU over the PCB board.

In Fig. 6., the connection of components that we have used in our project. To the top, the two ultrasonic sensors have been fixed. These two ultrasonic sensors detect the level of waste on either side of the bin. Exactly opposite to that is the infrared sensor which is used to sense the presence of waste once it is thrown in the bin. Besides is the temperature sensor, which is used to measure the temperature of the bin. Along the side is the air blower with the plastic sensor. This air blower is used to make the plastic waste fall off the other side of the bin when it is turned on, and in order to get better results, we have also used the plastic sensor. To the side of the rotating disk is the servomotor with which the disk is made to rotate.

In Fig. 7, the outlook of the prototype where sensors are attached to the sides. The plastic waste is separated from the reusable wastes using the air blower and in order

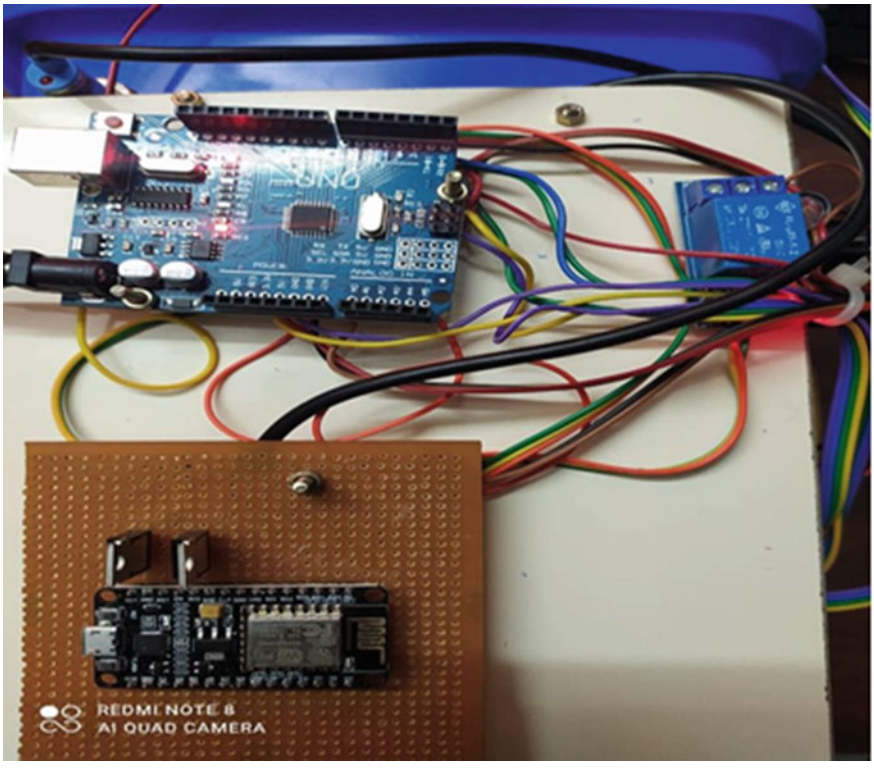


Fig. 5 Model Circuit

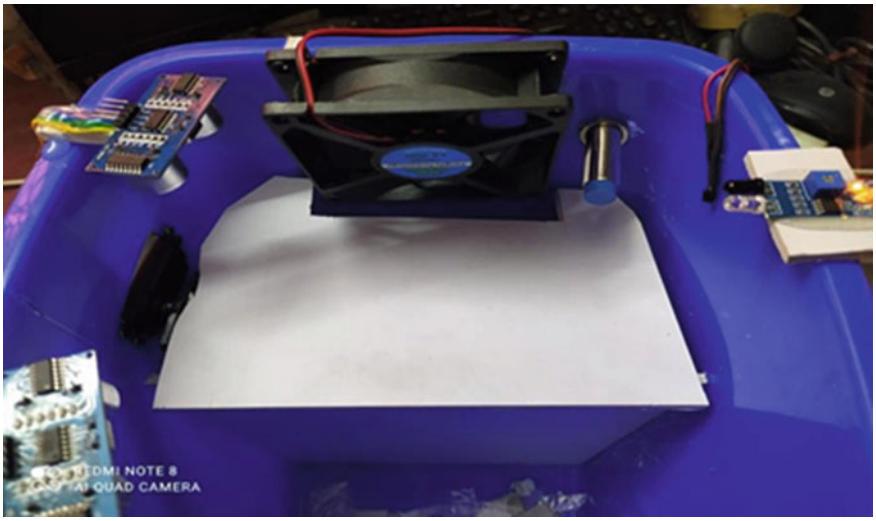


Fig. 6 Working model

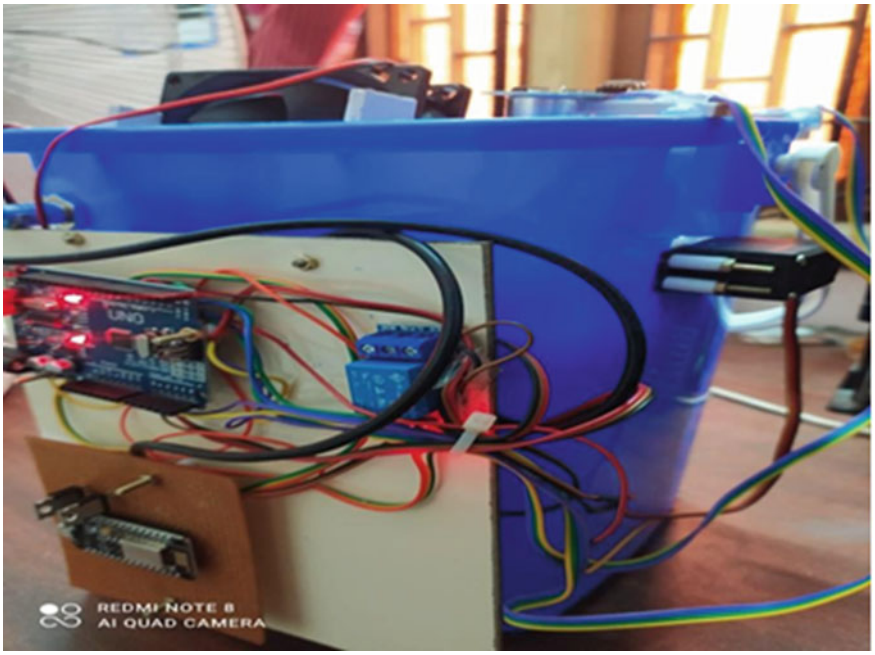


Fig. 7 Final outlet

to get more efficient results, the capacitive sensor comes into action which will sense the presence of the plastic. By this method, the plastic wastes will be separated from the reusable wastes. Then remains there usable wastes. The circular disk on top will rotate once the servo motor is turned on. There is a circular disk-like structure placed that contains the reusable wastes. When the servo motor is turned on, this disk-like structure is made to rotate, and is made to push downwards so that all the remaining reusable waste falls down inside the bin.

5 Experimental Explanation

In Fig. 8, we are performing the experiment by taking few plastic wrappers for plastic wastes and a wooden broken pencil and a vegetable to represent reusable waste. When the power supply is turned on, these wastes are placed on the rotating disk and the IR sensor senses the presence of these wastes. Then it will instruct the air blower to turn on through the Arduino Microcontroller.

In Fig. 9, the air blower blows off the plastic wastes to the plastic side of the bin since the density of plastic waste is considerably less than that of reusable waste, what

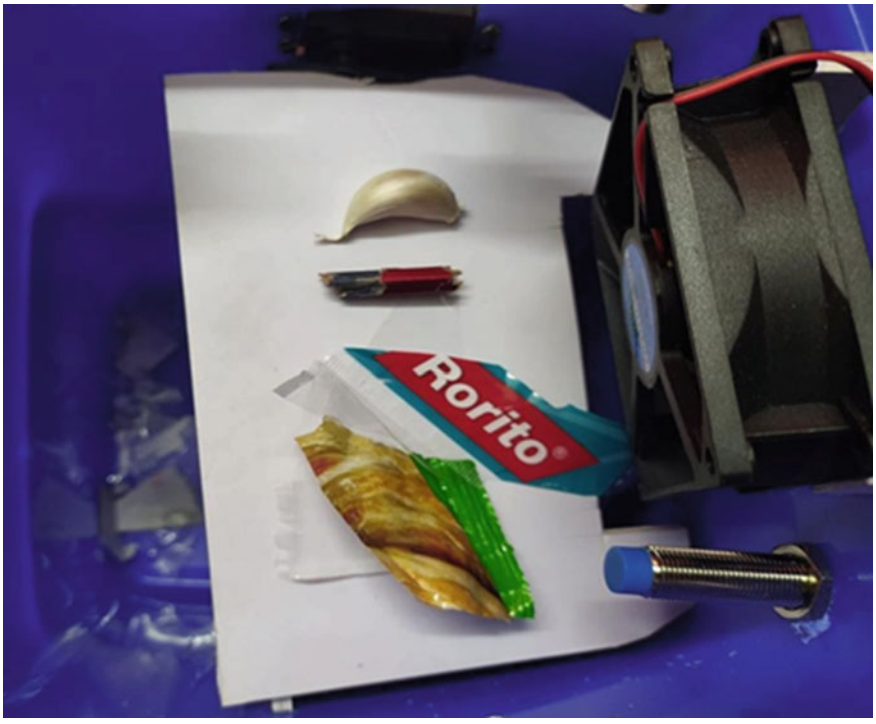


Fig. 8 Throwing the waste

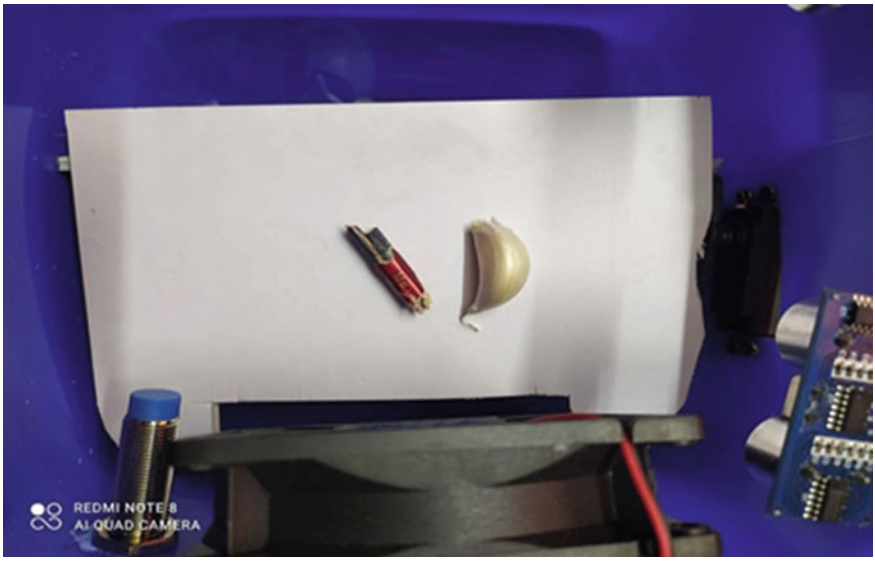


Fig. 9 Remaining reusable waste

remains on the top of the disk is the reusable wastes. After few seconds, the servo motor turns on which makes this disk to push itself downwards and the remaining reusable wastes are made to fall on the reusable side of the bin.

In Fig. 10, the final output of the first half of the project where the wastes are segregated into plastic and reusable waste and are made to fall on its respective sides of the bin using sensors and few components.

Figure 11 shows the outlook of the web page through which all the data collected by the cloud server system and which are accessed by the Wi-Fi module can be monitored. The information such as the temperature of the bin measured by a temperature sensor, the garbage level on either side of the bin is detected by the ultrasonic sensor and the date which shows when the last time the experiment has been performed was monitored.

In Fig. 12, the history button is clicked the results of previously performed experiments will be displayed. When the waste is about to overflow, with the alert message sent by the ultrasonic sensor the wastes from the waste management control room, the municipality will call for laborers to collect the waste from the garbage bin. This way not only the segregation of wastes is performed, but also we have made sure that the employment of daily labors is not affected.

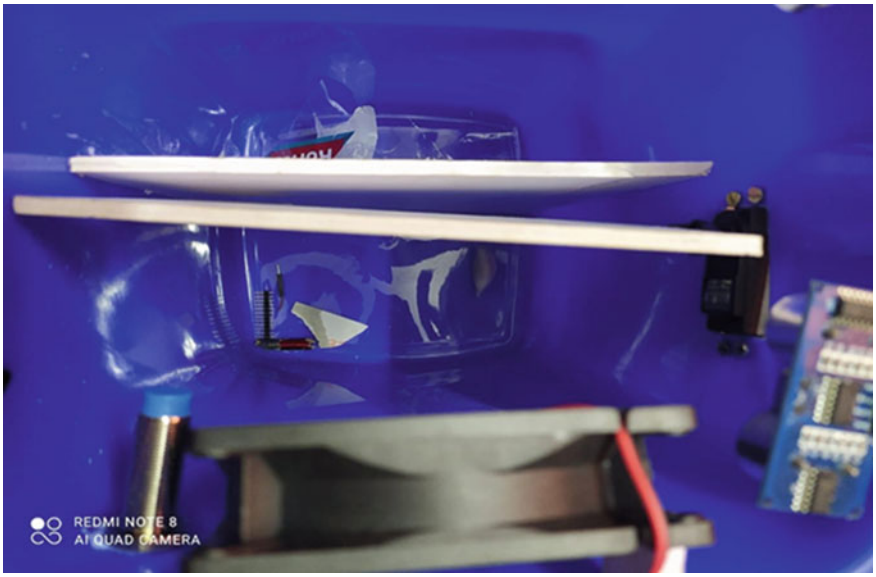


Fig. 10 Final output

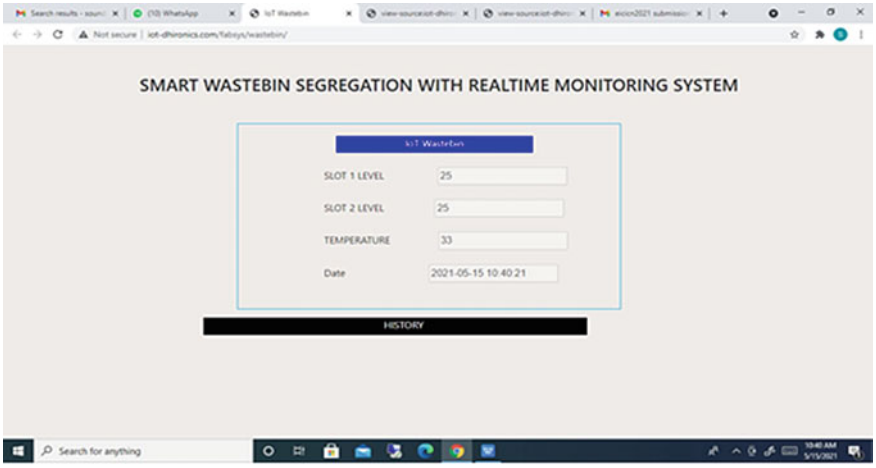


Fig. 11 The real time monitoring system output

6 Future Work

Every project has a scope of improvement. Perhaps the most pressing issue of parting of the waste is when they are disposed of instantaneously. The smart bin can be improvised further which would include the separation of wastes such as paper and

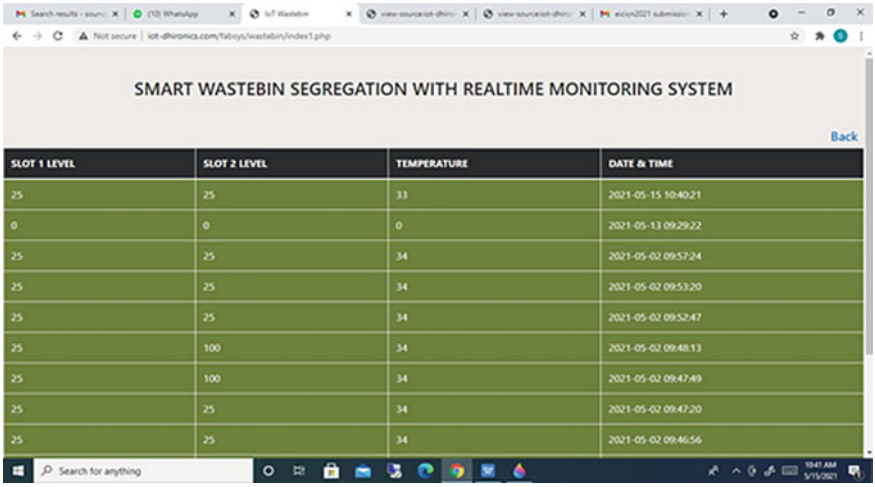


Fig. 12 The real time monitoring system output after segregation

plastic, safe segregation of biomedical waste generated at home, a compact and aesthetic Mechanical design.

7 Conclusion

The smart bins have various features such as durability, affordability, and accuracy. The Smart Dustbin can have a lot of contribution toward the clean neat and hygienic environment in the construction of a smart city. The advantages of the smart bins are: saves time for the segregation of waste; helps to keep our environment clean and green from the bad odor of wastes to improve the health of the environment to keep cities clean; reduces air pollution in the society. The cost of Infrastructure, operating, and maintenance will be reduced. The smart waste management process to the city will enhance the smart city. There few drawbacks in the system are, it requires a large number of bins for collecting the separated waste for the population in the city. The initial cost is expensive when compared to other methods. It also requires a well-structured hardware system.

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