Research Article

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Automatic waste segregator and monitoring system

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Abstract
Waste management is a collective process of collection, segregation, transport and disposal of waste to the appropriate locations. The segregation of different types of wastes is the most important issue faced while designing a waste segregation and monitoring system. As a result of which, the waste is still being segregated manually, thus producing a harmful effect on the segregator itself. This project reports an automatic segregator and monitoring system. Plastic recycling is a solution to this. Plastic recycling is the process of regaining plastic discarded as waste and reprocessing it in order to reuse it. The segregation section consists of ATmega328 as its main controller. It includes an inductive proximity sensor, capacitive proximity sensor and a moisture sensor in order to sense the type of waste. Automatic waste segregator classifies the waste as plastic, dry, wet and metallic. The waste collection process is monitored by the monitoring section. The automatic waste segregator and monitoring system is a cost-effective management system for segregation of plastic, dry, wet and metallic waste without the continuous attention of a person. A simple controller with inductive, capacitive proximity sensors and moisture sensor are used to make the system low cost and simple. The achieved results are as per the expected objectives, which provide proper segregation of waste, without manual intervention.

Keywords
Automatic waste segregator, Waste segregator and monitoring system, Waste recycling system, Prior segregation.

1.Introduction
Rising populace of India carries with itself a genuine hazard regarding the accessibility of living space, use of characteristic assets. The increasing amount of waste that is generated every minute is another serious risk that follows. Every city is managing the danger of ever-expanding waste. India produces around 60 million tons of waste each year. Ten million tons of trash is produced in metropolitan urban communities. India with a populace of 1.35 billion has per capita squander age going from 0.12 to 5.1 kg per individual and a normal of 0.45kg/capita/day [1]. The greater part of these urban areas has overflowing landfills, with no space for new trash. " waste management hierarchy " has been received by most countries as the progression for creating city strong waste (MSW) the executive's methodologies. IoT based waste management framework decreases the word related danger for squander laborers [2]. About 0.1 million tons of waste is created every day in India. Though, just 5% of the aggregate of waste is reused. In India, gathering the waste, moving the gathered waste and its removal are genuine issues. In India, city strong waste administration keeps on being an unadorned issue on account of ecological and stylish worries as well as because of the monstrous amounts of waste that is being created each day [3]. Despite the fact that about 31% of the number of inhabitants in India is available in urban zones, this populace of 377 million creates a colossal 1,43,449 metric tons for each day of civil strong waste, and these figures continue expanding day by day with an expansion in the populace [3].

A possible solution for this issue is the waste segregation at the initial stage itself. The initial stage can be considered as the disposal stage. India has implemented several ways to collect the waste materials separately as dry and wet, and also provided the municipal corporation with specially designed trucks for waste collection. But due to the unawareness of the citizens and their negligent behaviors, these methods do not benefit much [4].

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The separation of this collected domestic waste takes place at municipal factories using massive machines to satisfy the purpose. Also, the maintenance and disposal of this collected waste is an issue. A solution that is expected to help the quantity of usable assets is by introducing robotized receptacles which can perceive and arrange the kind of trash disposed of into the waste-canister. This refutes the effects of human carelessness and furthermore diminishes the probabilities of accessible recyclable materials getting sullied. We are along these lines advancing a programmed squander segregator and checking framework that groups this loss as wet, dry, metallic, and non-metallic. Isolation of waste forestalls the undesirable debasement of waste that could be reused, and stop the emanation of different destructive gases that could be discharged. Also, the IoT based monitoring system allows us to monitor the waste without manual attention at all times. The researchers have worked upon different frameworks to achieve the waste management issues like IoT enabled Automatic Waste Segregator as an integral part of the smart bin to segregate and store the waste [5]. IoT based Automatic Waste Segregator for efficient recycling and waste collection bins using Wi-Fi technology are used [6]. Automatic Waste Segregator and monitoring system using GSM technology used in [7].

Studies have been led utilizing a field explore way to deal with comprehend the impact of minimal effort impedances, for example, the arrangement of data at the family level which has not been done in creating nations. The investigation at that point overlays the mediations on standards and financial motivating forces on to 'data' intercession to show signs of improvement comprehension of the effect of mediations [8]. Scientists have additionally worked upon frameworks like Household Waste Management System Using IoT and Machine Learning [9], an AWS utilizing equal resounding impedance detecting component to recognize metallic things, and capacitive sensors to recognize wet and dry waste [10], an Automatic Waste segregator utilizing a mechanical arm [11], an Automatic Waste segregator utilizing Microcontroller based stage Arduino Mega 2560 load up which is interfaced with ESP8266 12E LoLin NodeMCU V3 module, Inductive vicinity sensor, Laser module, Light Dependent Resistor (LDR), Liquid sensor module and Ultrasonic sensor [12], an AWS utilizing Arduino UNO [13], a structure that empowered the remote checking of strong burn through receptacle continuously, by means of ZigBee-PRO and GPRS, for helping strong waste administration process [14], strong waste observing and the board framework utilizing radio recurrence ID (RFID) partner with canny frameworks [15].

The methodology being used incorporates the segregation and monitoring process. The segregation involves all the different kinds of sensors, with the help of which we separate the waste materials. The monitoring system makes use of IoT technology, giving us details about the capacity of the waste collecting bins. ThingSpeak is a platform used to carry out the monitoring process. Numerous administration bodies, the waste business, occupants, manufacturers, sellers, and business groups have acknowledged the obligation regarding overseeing strong waste. The PEARL activity is one of them [16]. For a sustainable community, an integrated system for waste disposal and management is a must. Such a framework secures general wellbeing, bolsters a dynamic economy, diminishes outflows of air contaminations, for example, ozone harming substances, moderate’s vitality and assets, and produces sustainable power source. The strong waste administration chain of importance underscores source decrease, reuse, reusing, organics recuperation, and asset recuperation over land removal. Urban IoT's, indeed, are intended to help the Smart City vision, which targets misusing the most exceptional correspondence innovations to help included worth administrations for the organization of the city and for the citizens [2].

The proposed method and system removed all aforementioned drawbacks and manufactured the prototype which fulfils the objectives such as; to segregate the waste in a proper and accurate manner, to save the revenue of segregation from landfills by segregation at an initial stage, to reduce manual intervention to a great extent and to collect the waste whenever required, without the continuous attention of the personnel.

2.Materials and methods

The system consists two parts: segregation and monitoring.

The segregation section consists of ATmega 328 as its main controller. It includes an inductive proximity sensor, capacitive proximity sensor and a moisture sensor in order to sense the type of waste. It also incorporates two stepper motors in order to rotate the drum and the flap. The main purpose of the segregation section is to sense the waste and separate

it from the other types of waste. When an item is thrown, the sensors identify it and a signal is sent to the stepper motors to rotate the drum to the identified section. The block diagram of the segregation section is given by *Figure 1*.

The Monitoring section consists of an ATmega328 as the main controller along with the four ultrasonic sensors for measuring the amount of garbage collected. It also consists of a Wi-Fi module esp8266 to develop communication with the remote computer for monitoring purpose, using ThingSpeak platform. *Figure 2* represents the block diagram of Monitoring section.

Initially, for the segregation part of the project, multiple sensors and motors are interfaced to the controller ATmega328. The moisture sensor, inductive proximity and capacitive proximity sensors along with the two stepper motors are initialized to the default conditions. These sensors are placed on a flap just below the inlet of the garbage collector. When a waste is thrown into the inlet opening and it falls on this flap, the sensors are actuated. If the detected waste is wet, the moisture sensor detects it and gives a signal to the controller that the sensed waste is wet. Accordingly, the controller sends a signal to the stepper motor which rotates the drum at angle of 0/3600 from the set reference point. If the detected waste is dry and non-metallic, it is sensed by the capacitive proximity sensor. For dry and non-metallic waste, the stepper motor is rotated at angle of 900 from the reference point on the drum. For metallic waste, the items are sensed using an inductive proximity sensor, the range of which can be varied. In case of metallic items, the stepper motor rotates the drum at an angle of 1800. After the sensing of the waste, and after the rotation of the drum to the respective sections, another signal is sent by the controller to the second stepper motor which is responsible to rotate the flap of the drum by an angle of 1800. When this flap is rotated by 1800, the waste on it falls in the particular drum. In this manner, the segregation of the waste is carried out. Now when the waste will be dropped in the drums, comes the part of the monitoring section.

The monitoring section has three ultrasonic sensors interfaced to the controller ATmega328. These ultrasonic sensors are placed in each of the drums at a fixed distance from the base. With the help of ultrasonic sensors, the level of waste in each of the drums can be monitored. With the help of Wi-Fi Module, this waste is monitored with the help of an IoT based platform called the ThingSpeak. Here a graphical representation of the waste added can also be viewed. After the bins are full up to the threshold, an alert message or a tweet is sent to the authorities concerned for collecting the waste. This helps to eliminate the manual intervention which was earlier required.

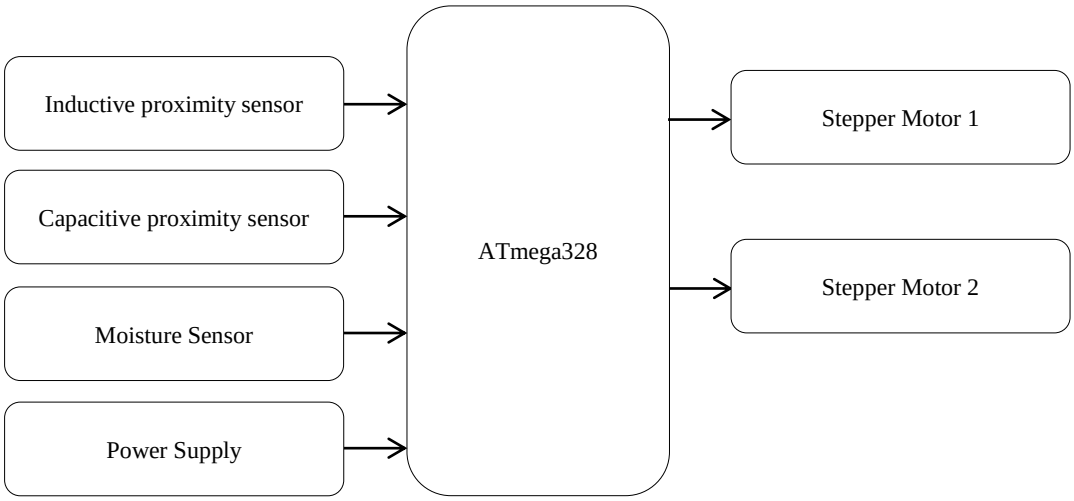

Figure 1 Segregation section

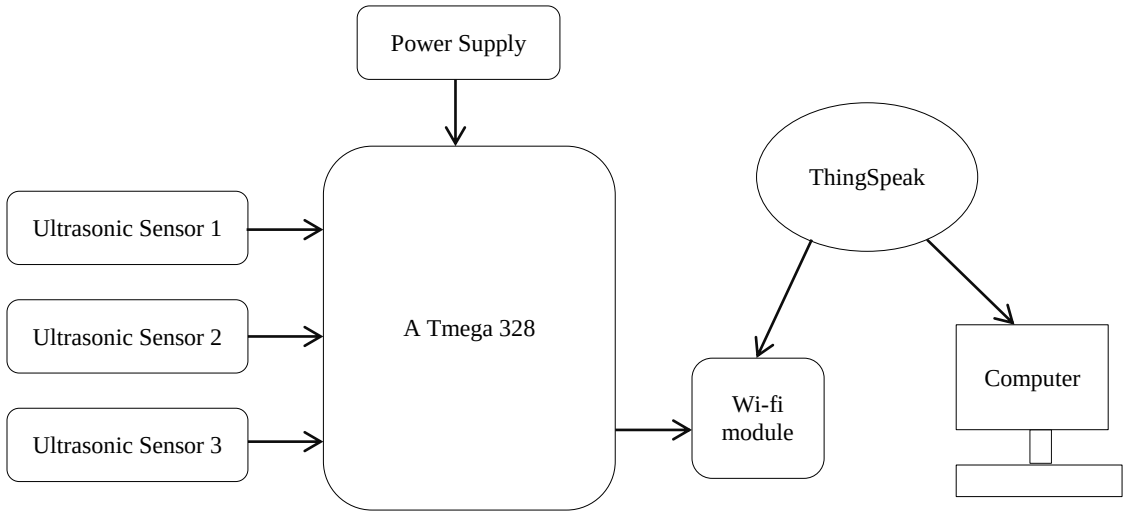

Figure 2 Monitoring section

2.1Software explanation

The monitoring section of the system makes use of a software IoT platform called as the ThingSpeak. ThingSpeak is an IoT analytics platform with the help of which one can aggregate, visualize and analyse live data streams in the cloud. ThingSpeak provides instant graphical visualizations of the data entered. In ThingSpeak, online analysis and data processing can be done, as it comes in. IoT includes the smart devices (the "things" in IoT) which collect data and include machines and sensors. Also, it incorporates the cloud where data from several sources is accumulated and analysed in real time, often by an IoT analytics platform designed for this purpose. It provides algorithm development where an engineer or data scientist gains insight into the collected data.

ThingSpeak fits in the cloud part provides a platform to quickly collect and analyse data. ThingSpeak allows you to collect, analyse and act on live data streams in the cloud. During the 'collect' stage, sensors perceive and measure data on various aspects like temperature, humidity, and pressure. This data is communicated in the form of numerical value or electrical signal. In 'analyse', by using analytical tools, data can be explored and visualized. Patterns and relationships between the data can be discovered. New data can be calculated. Visualization of data in the form of graphs and charts is possible. 'Acting' on data is something like sending a tweet or a message when a set threshold is achieved. More intricate actions can be set up like turning on of machines whenever the expected parameters are satisfied. Devices can also be controlled remotely.

2.2Algorithm and flowchart

2.2.1Algorithm

When a waste item falls onto the flap of the segregator, the motors and sensors which are previously set to their default conditions are activated. The waste is detected with the help of these sensors. If the waste is detected by the moisture sensor the drum rotates at an angle of 0/360 degree. If the waste is detected by an inductive proximity sensor then the drum rotates at an angle of 90 degrees. If the waste is detected by the capacitive proximity sensor then the drum rotates at an angle of 180 degrees. After that, the flap is rotated by 180 degrees and the waste falls in the respective drums. The level of waste in the drums is noted with the help of ultrasonic sensors. The graphical representation of the amount of waste is obtained on the Thingspeak platform. On reaching the predefined threshold values, a message or a tweet is sent to the concerned authorities.

2.2.2Flowchart

Figure 3 shows the system process flow.

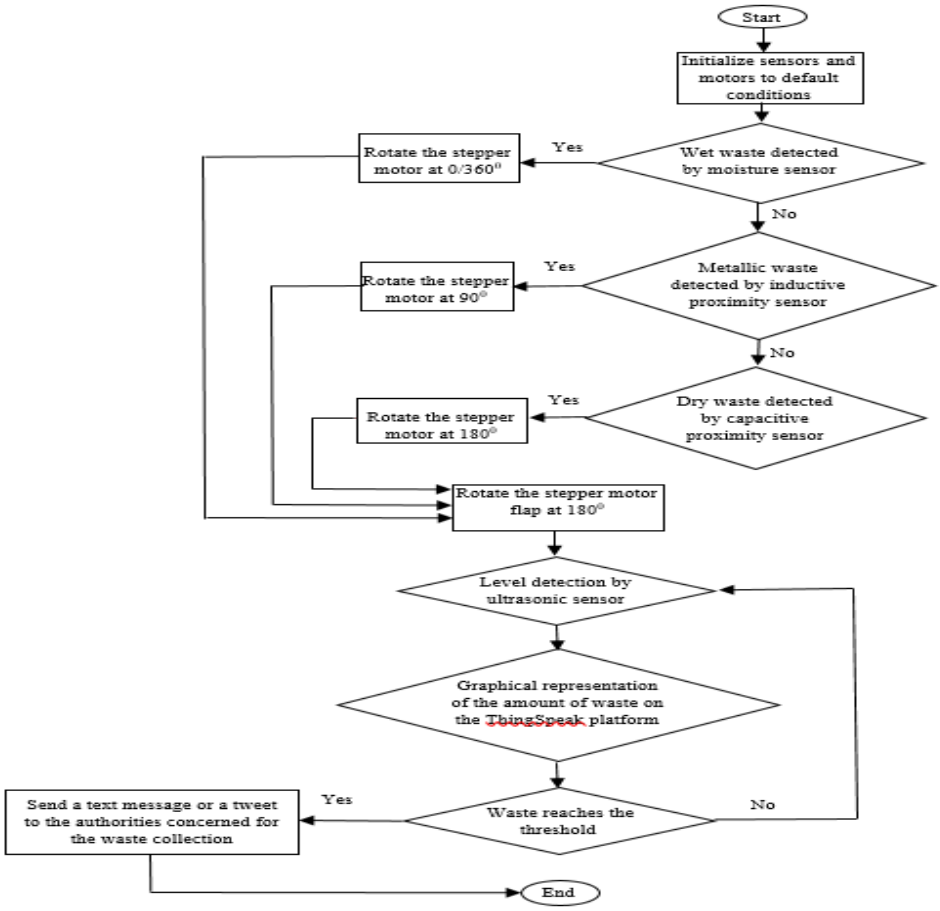

Figure 3 System process flow

3.Results

The performance parameters of the system have been shown in *Table 1*. The tables mentioned below show the sensor values and specifications collected by different types of sensors in the dustbin. *Table 2* shows the specifications of all parameters of prototype model. *Table 3* shows the data collected by capacitive proximity sensor in response to dry waste. The sensor returns value 1 if dry waste is detected, else it returns 0 for any other waste. Table 4 denotes the values collected by the Moisture sensor in response to the wet waste. The sensor returns a value corresponding to the moisture level present in the wet waste. *Table 4* shows the values recorded by an inductive proximity sensor in response to metallic waste. The sensor returns value 1 for metallic waste, else returns 0.

Graph 1 represents the graphical representation that can be obtained on the ThingSpeak platform. It keeps a real time record of the level of every type of waste in the bins. As shown in the graph, the level of wet waste detected by an ultrasonic sensor on the 12th of February is plotted, with level of waste on the y-axis and the time on the X-axis.

Since the predefined threshold is 80%, the platform will send a message or a tweet to the concerned authority when the value of level of waste crosses 80. According to this graph, ones the waste is collected, the value of the bin detected by the ultrasonic sensor again reaches 0%, indicating the waste has been collected. Figure 4 shows the level of wet waste in the bin.

Table 1 Performance parameters

S. No	Parameter	Specification
1	Segregation of waste	One at a time
2	Operating voltage and current	12V 5amp, 5V 2amp
3	Maximum bearable load per hour	20kg
4	Maintenance	After every 6 months, 2 years
5	Cost	Rs.4500

Table 2 Sensor values for dry waste

Sr No.	Dry waste segregation	
	Types of dry waste	**Sensor's Value**
1	Plastic bottle	1
2	Shampoo bottle	1
3	Food plastic box	1
4	Paper/Tissue	0

Table 3 Sensor values for dry waste

Sr No.	Wet waste segregation	
	Types of wet waste	**Sensor's Value**
1	Vegetables	350 - 590
2	Peel of fruit	560-750
3	Kitchen waste	250-550
4	Tea bags	100-550

Table 4 Sensor values for metallic waste

Sr No.	Metal waste segregation	
	Types of metal waste	**Sensor's value**
1	Battery	1
2	Food can	1
3	Drink can	1
4	Screw	1

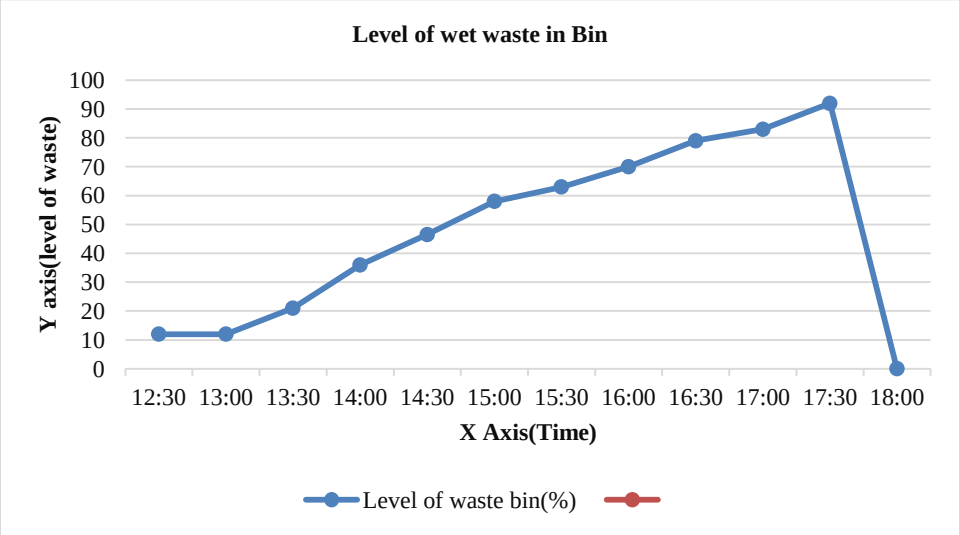

Figure 4 Level of wet waste in the bin

3.1Prototype

The prototype images of the proposed system have been shown in *Figures 5-9.* These pictures include the side view, top view, metallic, dry and wet waste segregation.

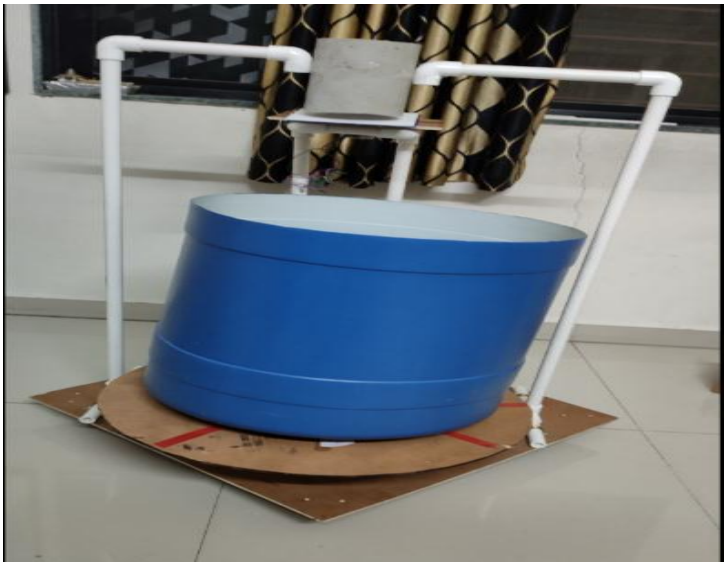

Figure 5 Automatic waste segregator and monitoring system

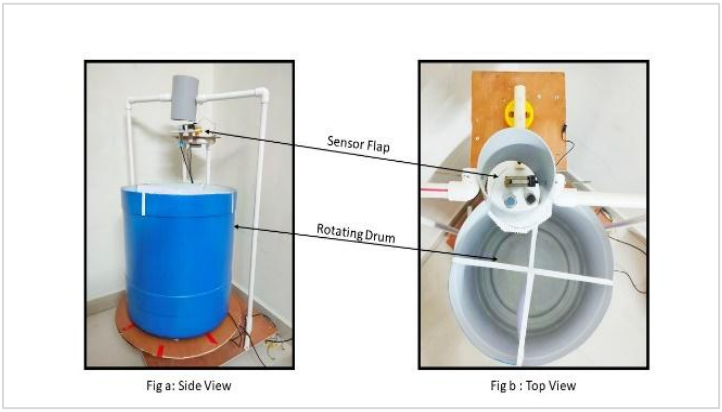

Figure 6 Side view and top views of the drum

Figure 7 Segregation of dry waste

Figure 8 Segregation of wet waste

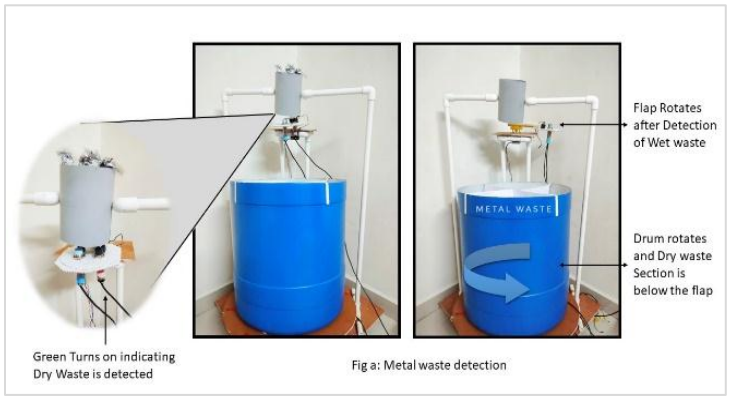

Figure 9 Segregation of metallic waste

4.Comparison of the system with traditional approaches

In reference [7], typically, a GSM module was consolidated in the observing area of the AWS. A similar data transmission being shared by various clients is the significant disadvantage of GSM innovation. The transmission can run over impedance with enough clients. Our undertaking utilizes ThingSpeak IoT which permits you to total, picture, and dissect live information streams in the cloud. A portion of the key capacities of ThingSpeak incorporate the capacity to: Easily design gadgets to send information to ThingSpeak utilizing mainstream IoT conventions, Visualize your sensor information continuously.

As mentioned in reference [11], a robotic arm has been made use of in this traditional approach. The robotic arm adds to the technical complexity of the system. This leads to an increase in the field area consumption of the site of the system. The introduction of a robotic arm also is a costly approach in order to segregate the waste. The purpose of the arm was to segregate the waste items without manual intervention, which our system fulfills with the installation of sensors and stepper motors in order to rotate the drum segregate the waste. Thus, overcoming the drawbacks of the GSM module, the Thingspeak IoT platform has been successfully introduced into the project. Also, the drawbacks of the robotic arm have been overcome and the necessary replacements have been incorporated in our system.

5.Discussions

The different frameworks which have been worked upon to achieve the waste management issues include systems like IoT enabled Automatic Waste Segregator. This was a smart dustbin used in order to segregate and store the waste, whereas the proposed system has accompanied this along with other modifications. Also, an IoT based Automatic Waste Segregator was designed for efficient recycling. This system makes use of IoT like in the mentioned system. IoT based Waste Collection bins using Wi-Fi technology were also designed to serve the purpose previously, the Wi-Fi technology has been used in the monitoring section. Automatic Waste Segregator and

Monitoring system using GSM technology has been executed before, but not been incorporated in this system.

6.Conclusions

The automatic waste segregator and monitoring system is a cost-effective management system for segregation of plastic, dry, wet and metallic waste without the continuous attention of a person. A simple controller with inductive, capacitive proximity sensors and moisture sensor are used to make the system low cast and simple. The components used are easily available in the market for bulk production. The model is implemented in food malls, movie plazas, public parks, gardens and tested successfully.
The system can be further improved with the used of object detection using image processing. This method can identify the incoming objects using a previously fed database of the objects. With further research, image processing can be implemented to detect the waste and a few sensors can be replaced with it. Thermal conversion is another technology that can be implemented in the existing system. It could be used to turn the waste into chemicals, fertilizers, oils, and other useful products. The system can also be made intelligent, by adding AI and ML algorithms to train the system in order to segregate and monitor the waste.

Acknowledgment

None.

Conflicts of interest

The authors have no conflicts of interest to declare.

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