AUTOMATIC WASTE SEGREGATOR

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***Abstract*—In India, the most crucial threat that adds up is the striking amount of waste generated every day by a human being. Around 62 million tonnes of waste is produced each day by 377 million people living in urban India of which 45 million of waste is left untreated and disposed unhygienically causing severe health issues and environmental degradation. Ultimate destination of solid waste in India is at disposal. Thus, a practicable answer could be separating the waste at disposal level. This paper aims to sort the waste into three major classes, namely metallic, wet and dry and further separating dry into paper and plastic. The most important feature of this work is that, it is not only cost efficient but also compact with a simpler design thereby making the waste management system more persuasive. In this paper, we are using Arduino UNO which makes the working of the system to be smooth and convenient making the design to be less complicated. Each of these wastes are detected by the respective sensors and discarded into the bins assigned to them wherein these wastes can be taken for recycling or reusing directly.**

Keywords—Automation,Waste segregation,Inductive Proximity Sensor,Soil Moisture Sensor,LASER LDR Module,Slot Mechanism

I. INTRODUCTION

A rage of notable inflation in municipal solid waste generation has been registered worldwide. This has been found due to over population, industrialization, urbanization and economic growth and have caused immense effect on solid waste generation. Overflowing landfills are impossible to reclaim because of the unruly accumulation of wastes on outskirts of cities rooting vital environmental enlace in terms of water pollution and global warming. This has caused the average life time of the manual segregators to reduce [1].

In India, rag pickers play a crucial role in the recycling of urban solid waste. Rag pickers and conservancy staff have higher jejuneness due to infections of skin, respiratory system, gastrointestinal tract and other allergic disorders. Hinging on the rag-pickers can be diminished if segregation takes place at the source of municipal waste generation. The benefits of doing so are that a higher quality of the material is preserved for recycling which means that more value could be recaptured from the waste. The occupational hazard for rag pickers is reduced. Also, the segregated waste can be directly sent to the recycling and processing plant instead of sending it to the segregation plant and then to the recycling plant [2].

The economic value of the waste generated is not realized unless it is recycled completely and there are different techniques available to recycle and reuse the municipal solid waste [3], [4]. When the waste is segregated into basic categories such as wet, dry and metallic, it has an intense prospective of improvement, and accordingly, recycled and reused. The wet waste fraction is often converted either into compost or methane gas or both. Compost can replace demand for chemical fertilizers, and biogas can be used as a source of energy. The metallic, plastic and paper waste can be reused or recycled [2]. A model is proposed to segregate E-waste by combining data mining process and knowledge management process is proposed in [5]

In [6] it shows the use of RFID for waste segregation. This system is not viable, as not all companies would add to their cost of applying RFID tags to their products thus implementation of such system is difficult and not economical. Also the use of RFID scanner like devices in harsh and non-suitable condition would only add to the difficulty. In [7] it shows the use of PLC for segregation. This again, has a drawback of complexity as it uses all the sensors to be clamped on a conveyor belt that is controlled by the PLC. It only shows the segregation of metal, glass and plastic wastes. This makes the system rambled, huge and complicated. In [1] 8051 Microcontroller is used to interface the sensors used for waste segregation. This system is more time consuming and the expansion of the circuit is difficult. It also uses blower mechanism to separate dry and wet waste based on their density which is not feasible if both dry and wet has the same density. In this system, it segregates only dry, wet and metal wherein it dumps all the dry wastes together without segregating them. Here, all the wastes are thrown on a conveyor belt thus making the system large and complex. In [8] it only shows the segregation of glass and metal wastes.

Presently, there is no automated system for segregation of wet, metallic and dry wastes where it further segregates dry into plastic and paper at domestic level. This paper shows the working of an automatic waste segregator using Arduino UNO and different sensors for detecting each type of waste i.e. wet, metal, paper and plastic. There are two circular discs where one being stationary and the other one rotatory. The sensors are placed on poles that are fixed on the stationary disc. The waste is kept on a slot cut on the rotating disc which moves to each sensor to detect the type of waste thus, opening the slot if

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detected correctly which ultimately falls into the respective bin kept below each sensor on the stationary disc. Fig 1 shows the description of the model. The purpose of this project is the realization of a compact, low cost and user friendly segregation system for urban households to streamline the waste management process.

The organization of the paper is as follows. Section II describes the proposed solution. The execution of the model is explained in section III. Section IV gives the results and the tabulations based on the same. A detailed conclusion including limitations and future scope is provided in section V.

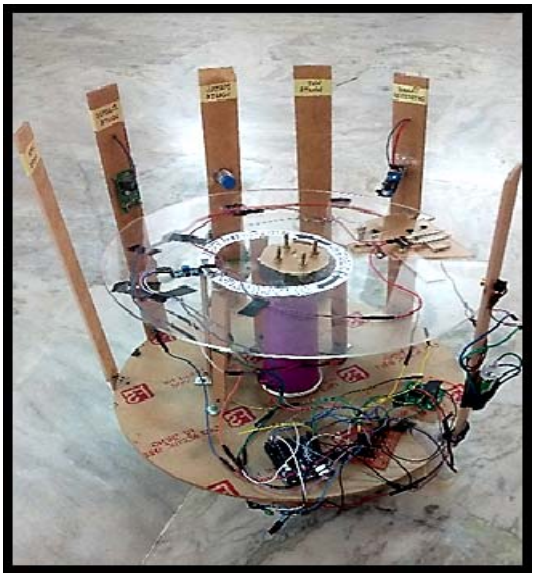

Fig. 1. Automatic Waste Segregator

II. Proposed Solution

Figure 1 shows a diagram of the Automatic Waste Segregator. There are two discs; upper and lower, one of them being rotating and the other stationary. Waste is kept on the specified position that is a slot on a rotating disc. An IR proximity sensor detects the waste and starts the entire system. Waste then keeps rotating on the disc and comes under the range of the first sensor which is the Moisture sensor for wet waste detection. If the waste is not detected as wet waste it goes to the next sensor that is Inductive Proximity sensor for the metal detection. This sensor is used to detect any metal waste in its vicinity. After the detection the trash comes under the succeeding sensor if not detected as metal. This module is a Laser LDR circuit that detects dry waste (plastic and paper). Once the waste is detected by any of the sensors the slot on which the waste is kept bends and falls into its respective bin with the help of Servo Motor. These bins are placed exactly below each sensors so that the trash can fall immediately after detection. These bins are kept between the rotating disc and the stationary disc, which are at a certain distance. Figure 2 shows the block diagram of the proposed design.

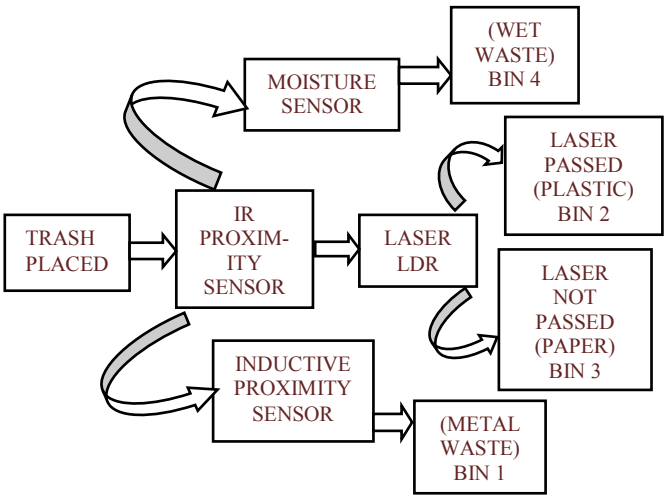

Fig. 2. Block Diagram of Proposed Model

III. Execution With Individual Modules

The IR proximity sensor sends an interrupt to the microcontroller Arduino UNO when the trash is detected. A LASER light is kept continuously ON as soon as the trash is detected. This light is placed exactly opposite to the LDR module. The trash is then moved to the moisture sensor. If the trash is detected as wet waste it falls into its bin else it is moved to the next sensor in the queue. The next sensor is the inductive proximity sensor for metal detection. If the trash is considered to be metal it falls into the bin assigned for it else it is moved to the next sensor. The next sensor is the LDR LASER module for plastic and paper detection. If the LASER kept opposite to it passes through the trash it is detected as plastic else as paper. A DC geared motor is used to rotate the disc which is the upper disc. The slot has a servo motor to bend so that the trash falls into the respective bins. Figure 3 shows the placing of each sensor and motor. The individual modules are explained in the following section.

A. Entry System and Initialization

The waste is kept on the slot of the rotating disc. This slot comes in the proximity of the IR proximity sensor which marks the entry of the waste. The digital pin of the sensor is given to the Arduino as an input because it can trigger an activity when the distance falls below the threshold set by the potentiometer. A LASER is also kept on the disc which is continuously ON once the IR detects the trash. If the object is close, the reflected light will be stronger than if the object is farther away. Immediately the sensor sends an interrupt to the microcontroller that is Arduino UNO. The output of the sensor is digital and hence is attached to the digital pin of the Arduino UNO. This microcontroller then initializes all the sensor modules. This initialization of all modules ensures that any dynamic changes in the environment do not affect the sensing. Once the trash has been detected by this sensor it then moves forward to the next sensor for the material detection.

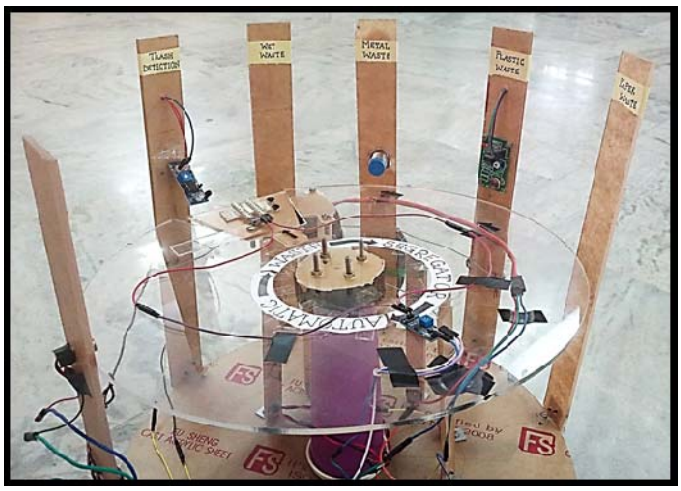

Fig. 3. Placing of sensors and connections

B. Wet Detection System

After the trash has been detected by the IR sensor, it is moved to the first sensor to detect the type of waste. This is the moisture sensor, which identifies if it is a wet waste or a dry waste. This sensor is placed on the slot i.e. the trash is kept onto this sensor as it is a contacting sensor. According to the module once when the trash is kept on the sensing region of the sensor, it gives a signal to the microcontroller to check with the range which is given in the code for dry and wet respectively. The output of the sensor is analog and the range is given as digital values between 0-1023. If it comes in the range of wet, then it is indentified as wet waste and thus falls into the respective bin which is below the sensor. Otherwise it is indentified as dry waste and moves to the next sensor for detection.

The moisture sensor uses capacitance to measure dielectric permittivity of the ambience. In trash, dielectric permittivity is a function of the water content. The sensor produces a voltage proportional to the dielectric permittivity, and thus the amount of water content in the trash. It detects the trash within 2cm of the length of the sensor and has no sensitivity at its extreme edges. This sensor has two probes through which current passes in soil, then read the resistance of trash for reading moisture level. The water content in the trash is more prone to electric conductivity resulting less resistance in trash where on the other hand dry trash has poor electrical conductivity thus more resistance in trash. Inside the sensor there are circuitry for measuring the resistance and converting it into voltage as output. The moisture sensor module, built around the LM393 comparator, gives an active-low output when the trash is dry (determined by a preset threshold value). This analog output is routed to one I/O terminal of the Arduino microcontroller. Based on this input, Arduino shows when the trash is dry and when it is wet.

C. Metal Detection System

After the trash is detected as dry waste it is further moved to the next sensor which is the inductive proximity sensor (M18DPO) to identify if the trash is a metal. Once when the trash is in the vicinity of the sensor, it gives a signal to the microcontroller to check with the range which is given in the code. The range is given as a digital value between 0-1023 whereas the output of the sensor is analog. If the trash falls under the particular range as per the code it is declared as metal waste and falls into the respective bin. Otherwise the trash is moved to the next sensor.

An inductive proximity sensor includes an oscillator, a ferrite core with coil, a detector circuit, an output circuit, housing, and a cable or connector. The oscillator produces a sine wave with a stable frequency. This signal is used to run the coil. The coil along with ferrite core causes an electromagnetic field. When the field lines comes in contact with a metal object, the oscillator voltage is decreased, proportional to the size & distance of the trash from the coil. The deduction in the oscillator voltage is due to the eddy currents produced in the metal in contact with the field lines. This deduction in voltage of the oscillator is detected. Inductive proximity sensor is used to segregate different metallic materials according to the amount of current produced by the change in the magnetic field of the sensor. The variation in current is directly proportional to the distance of the metallic material from the sensor and accordingly metal is detected [9].

D. Paper and Plastic Detection System

If the metal sensor fails to detect the trash, it is further moved to the next sensor that is the LASER LDR module [4]. The LASER which is continuously ON during the process now falls on the LDR through the trash kept on the slot to detect it as plastic or paper. When the LASER passes through the trash then the sensor sends an interrupt to the microcontroller and checks the range of intensity of light given as a threshold value in the code. The output of this sensor is analog. The LDR gives an analog voltage when attached to Vcc (5V), which varies in magnitude and directly proportional to the input light intensity on it. Greater the intensity of light, more will be the output voltage from the LDR. Since the LDR gives an analog voltage, it is attached to the analog input pin on the Arduino UNO. The Arduino, with its built-in analog to digital converter, then converts the analog voltage from 0-5V into a digital value in the range of 0-1023. When there is sufficient light on its surface, the converted digital values read from the LDR through the Arduino will be in the range of 400-1023. When the full intensity of light falls on the LDR, the trash is detected as plastic and is fallen into the respective bin. Otherwise it is detected as paper and is fallen into another bin.

When there is enough light, the resistance of LDR will become low according to the intensity of light. The greater the intensity of light, the lower the resistance of LDR.

E. Segregation Module

To achieve the segregation that is to rotate the disc, a DC geared motor is used. They are less expensive compared to the stepper motor. The disc is mounted on the axle of a DC geared motor. The disc rotates as the axle of the DC geared motor rotates. When the respective material is being detected the disc stops the rotation. This interrupt is used to stop the motor by the microcontroller. To avoid overshooting due to the momentum of the base, the DC geared motor is rotated at lower speeds by using pulse width modulation (PWM) which is generated from the microcontroller's timer [2]. When the IR proximity sensor detects the trash in its vicinity, the microcontroller gets an interrupt due to which the DC gear motor starts rotating clockwise with a given delay towards the first sensor. After the material is detected, the disc stops rotating and is positioned under the particular sensor. Then a DC servo motor (MG995) is used to lower the slot which is cut on the rotating disc. It then waits for some time to ensure that the waste falls down and finally raises the slot back to the initial position by rotating the motor anti clockwise by 90°. PWM is used to rotate the motor. The trash then falls into the respective bin. If the trash is not detected according to the sensor it moves anticlockwise to the original position i.e. to the IR proximity sensor.

A gear motor produces high torque with a low speed motor output. Geared DC motors can be defined as an extension of DC motor. A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as rpm. Figure 4 shows the DC Gear Motor used for rotating the upper disc.

Servo motor can turn 90 degree from either direction form its neutral position. The angle of rotation of the servo motor is controlled by the duration of applied PWM pulse to its control pin. Basically, servo motor is made up of DC motor which is controlled by a variable and some gears. High speed force of DC motor is converted into torque by gears. In Servo motor force is high and distance is less. Figure 5 shows the servo motor placed below the slot for bending.

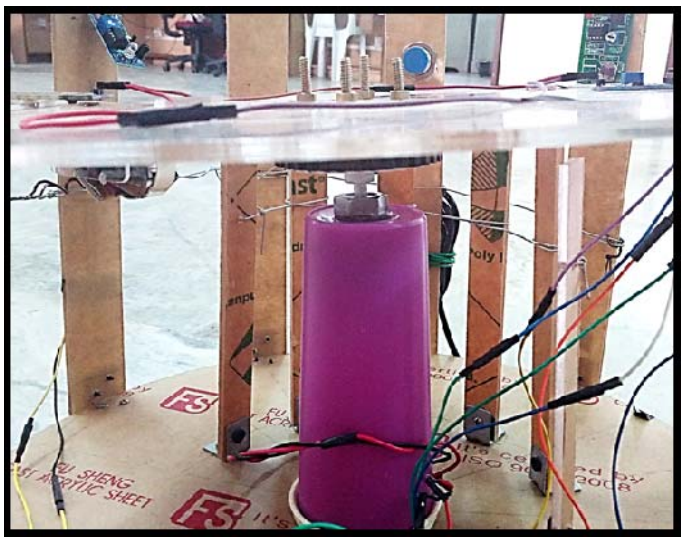

Fig. 4. DC Gear Motor

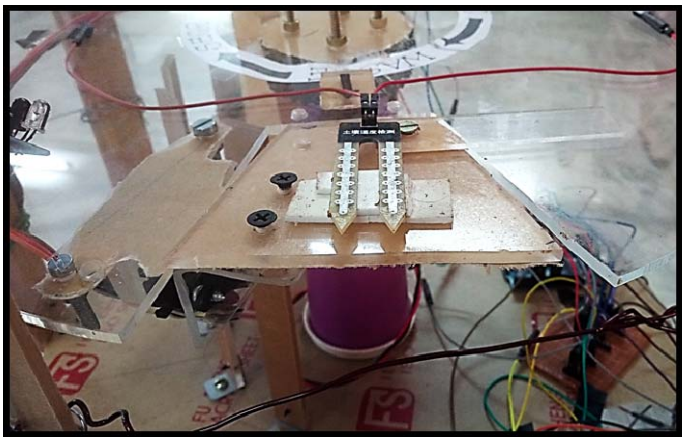

Fig. 5 . DC Servo Motor for Slot Mechanism

IV. RESULTS

The interfacing of all the sensors has been carried out using Arduino UNO. The IR proximity sensor is used to identify the presence of the trash kept. Once it is detected the disc rotates clockwise and moves to the next sensor which is in the queue as per the model design and the code in the Arduino considering the delay time. A LASER light is kept continuously ON as soon as the IR sensor detects. When trash is not detected by the sensor it shows 'waiting' as per the code which indicates that the sensor is waiting for the trash to come under its range.

Once it is detected it is moved to the next sensor as the disc rotates clockwise to the Moisture sensor which indicates if the trash which is present in its range is a wet waste or dry waste depending on its dielectric value. A range in digital value between 0-1023 is mentioned in its respective code according to which it says wet or dry. If the trash is detected as wet waste, it falls into its respective bin which is placed below the sensor i.e on the stationary disc. The disc then rotates anti clockwise and comes back to the original position.

After being detected as dry waste the disc rotates clockwise and it moves to the next sensor which is an inductive proximity sensor (M18DPO) that shows if the trash is metallic or not due to the amount of current generated caused by the change in magnetic field of the sensor. The threshold value is given as a digital value between 0-1023 using a software program in the Arduino and accordingly metal is detected. The metal then falls into its bin which is below the sensor. The disc rotates anticlockwise and comes to its original position.

If the trash is not detected as metal it is moved to the range of next sensor as the disc rotates clockwise to the LASER LDR Module where if the LASER falls on the LDR it is recognized as plastic, thus falling into the respective bin. The disc then rotates anticlockwise to the initial position. If the LASER fails to pass then the material is decided as paper and the disc rotates clockwise with a given delay and the trash falls into the bin. The disc then moves anticlockwise to the initial position. Whenever the laser beam falls on the LDR Module it sends an interrupt to the Arduino. LDR sensor module detects the intensity of light falling on it. A threshold value for the amount of light intensity from the LASER falling on the LDR is given in the program which is between 400-1023 for detecting it as plastic or paper respectively.

Thus the segregation is complete and the microcontroller waits until the entry of the next waste material into the system.

The tables that succeeds shows the analysis carried out in the detection of the waste when showed up to this automatic waste segregator. This project has been tested with varied categories of waste which is metal, paper, plastic and wet. Each of these categories has been trialed with an acceptance and rejection rate with this system. The tabulation of the domestic wastes that abides to the system design of classification on the type of waste is held that will come under true or false acceptance and rejection. True Acceptance is a part that accurately discerns and segregates the waste. True Rejection is a part that will recognize an incorrect waste and discard it. In False Acceptance, it will discern a wrong waste to be true. False Rejection is when it will not recognize or accept and thus discards the waste [1].

TABLE I. Metal Waste Segregation

SR. NO.	TYPES OF METAL WASTE	DISCARD
1.	Safety Pins	No
2.	Paper Clips	No
3.	Batteries	Yes
4.	Nails	Yes
5.	Tinned Cans	Yes

TABLE II. Acceptance and Rejection of Metal Waste

SR. NO	TYPES OF METAL WASTE	TRUE ACCEPT	TRUE REJECT	FALSE ACCEPT	FALSE REJECT
1.	Safety Pins	40%	-	-	60%
2.	Paper Clips	40%	-	-	60%
3.	Batteries	100%	-	-	-
4.	Nails	70%	-	-	30%
5.	Tinned Cans	100%	-	-	-

TABLE III. Plastic Waste Segregation

SR. NO.	TYPES OF PLASTIC WASTE	DISCARD
1.	Plastic Box	Yes
2.	Plastic Bottle	Yes
3.	Non- Transparent Plastic	No
4.	Coloured Plastic (Transparent)	Yes
5.	Milk Cover	No

TABLE IV. Acceptance and Rejection of Plastic Waste

SR. NO	TYPES OF PLASTIC WASTE	TRUE ACCEPT	TRUE REJECT	FALSE ACCEPT	FALSE REJECT
1.	Plastic bottle	100%	-	-	-
2.	Plastic box	100%	-	-	-
3.	Non-transparent Plastic	-	-	-	100%
4.	Coloured Plastic	10%	-	-	90%
5.	Milk Cover	-	-	-	100%

TABLE V. Paper Waste Segregation

SR. NO.	TYPES OF PAPER WASTE	DISCARD
1.	Paper	Yes
2.	Tissue	Yes
3.	Cardboard	Yes
4.	Carton	No
5.	Tetra pack	No
6.	Milk cover	Yes

TABLE VI. Acceptance and Rejection of Paper Waste

SR. NO	TYPES OF PAPER WASTE	TRUE ACCEPT	TRUE REJECT	FALSE ACCEPT	FALSE REJECT
1.	Papers	100%	-	-	-
2.	Tissue	30%	-	70%	-
3.	Cardboard	100%	-	-	-
4.	Tetra pack	-	-	100%	-

TABLE VII. Wet Waste Segregation

SR. NO.	TYPES OF WET WASTE	DISCARD
1.	Vegetable Peels	Yes
2.	Fruit Peels	Yes
3.	Kitchen Waste	Yes
4.	Tea Bag	Yes
5.	Chilled Can	Yes

TABLE VIII. Acceptance and Rejection of Wet Waste

SR. NO	TYPES OF WET WASTE	TRUE ACCEPT	TRUE REJECT	FALSE ACCEPT	FALSE REJECT
1.	Vegetable Peels	100%	-	-	-
2.	Fruit Peels	100%	-	-	-
3.	Kitchen Waste	100%	-	-	-
4.	Tea Bag	100%	-	-	-
5.	Chilled Can	90%	-	-	10%

V. CONCLUSION

This work proposed an automatic waste segregator that can segregate wet, metal plastic and paper. This can be largely implemented in various municipal corporations and places like airport or railway stations, taking into consideration various factors such as reduction in manpower and increase speed of waste management. The interfacing of all the sensors has been done using Arduino UNO. The IR Proximity sensor is used to detect the trash kept and moves to the next sensor which is in the queue as per the model design and the code in the Arduino. Once it is detected it is moved to the next sensor that is the Moisture sensor which indicates if the trash which is present is a wet or dry waste. After being detected as dry waste it moves to the next sensor which is an Inductive Proximity sensor that shows if the trash is metallic or not. Next sensor is the LASER LDR Module where if the LASER falls on the LDR it is recognized as Plastic, if it fails to pass then the material is decided as Paper.

Few of the limitations of this model includes, size of the trash should fit the slot size i.e. 100mm X 85mm and the width of the trash should be minimum of 30mm. The system can segregate only one type of waste at a time with an assigned priority for wet, metal and dry waste. The segregation of non-transparent plastic is not possible due to low intensity of LASER light.

The design of the model can be made bigger with a larger dimension which can therefore increase the slot size and hence wastes that are in larger sizes can be segregated as well. Improvements can be made to segregate mixed type of waste with the help of image processing. Provisions can be made for on spot decomposition of wet waste. Development can be made on the sensor to detect any type of plastic. Allocations can be made for a sieve (wire mesh) inside every bin to separate the smaller dust particles in the system. A robotic arm can be used to reposition an object in certain direction.

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