SMART WASTE MANAGEMENT SYSTEM

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Under the Guidance of

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1. Introduction

India's garbage generation stands at 0.2 to 0.6 kilograms of garbage per head per day. Segregation at source is crucial for clean cities. India's per capita waste generation is so high, that it creates a crisis if the garbage collector doesn't visit a neighborhood for a couple of days. Improper waste disposal causes problems that cause degradation of the environment.
Waste has been piling up in many dumping grounds all over India. Most of this waste is in mixed form and hence cannot be disposed off effectively. The most commonly used waste handling techniques are burning of waste or using it as landfill. The waste is not subjected to recycling, composting, or any other form of environmental treatment.

Hazardous toxic wastes lie side by side with the organic wastes in the landfill. It should be imperative on the part of municipalities to separate the biodegradable from nonbiodegradable waste. Biodegradable wastes can then be subjected to composting. Wastes like plastic, metal, paper etc. can also be subjected to recycling. In some ways, the waste can actually serve as a resource. By separating waste into different categories we can implement processes that will lead to effective resource utilization. This could be implemented at individual as well as society level.

The economic value of the waste generated is realized after it is recycled completely and there are different techniques available to recycle and reuse the municipal solid waste. When the waste is segregated into basic categories such as wet, dry and metallic, it has an intense perspective of improvement, and accordingly, recycled and reused. Thus in this project, we have done a comprehensive survey of different existing techniques for automation of waste segregation.

1.1 Categories Of Waste

1.1 Liquid Waste-Liquid waste is usually found both in homes as well as in industries. It includes dirty water, wash water, organic liquids, even rainwater, and waste detergents.
1.2 Solid Waste- Solid waste can include items found in your household along with commercial and industrial locations. Commonly broken down into several types.

1.2.1 Paper Waste- Includes packaging material, newspapers, cardboard, etc. Paper can be recycled and reused thus should be disposed of in recycling bin.
1.2.2 Metals- Mostly generated as industrial or household waste. It can be recycled thus should be preferably disposed of separately.
1.2.3 Plastic Waste – Consists of bags, jars, bottles, etc. that can be found in the household. It is non-biodegradable, but most of them can be recycled.

Plastic should not be mixed with regular waste, it should be sorted and placed in a separate bin. Recycling of plastic overcomes energy usage up to 90%.

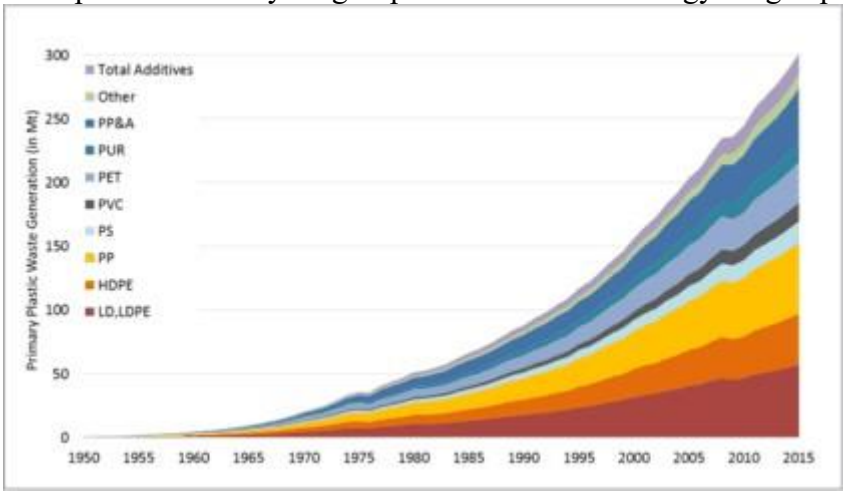


Fig.1 Source-https://cosmosmagazine.com/society/global-plastic-wastetotals-4-9billion-tonnes

Above figure * shows different types of plastic waste generated from 1950 to 2015. It was observed that PP&A, PUR, and PVC contributes the maximum to the plastic wastes. The most common polymers in the waste stream were polythene and polypropylene, which account for under half of all the waste plastics produced. This is majorly due to the widespread use of packaging plastic and nonrecyclable plastic.

1.2.4 Ceramics and glass- Ceramic wastes are separated into two categories in accordance with the source of raw materials. One category is formed through generated fired ceramic wastes by structural ceramic factories that use only red pastes for product manufacture. The second encompasses fired ceramic waste which is produced in stoneware ceramic. It is 100% recyclable since the process of melting used glass requires far less energy compared to the production of glass from virgin materials. Currently, up to 60% of transparent and 90% of green glass bottles in Europe are already made of recycled glass.

1.3 Organic Waste- Organic waste includes food waste, garden waste, manure, and rotten meat are classified as organic waste. Approximately 300400 kg of compost can be produced from 1 ton of biodegradable waste and can be utilized as organic fertilizer in agriculture or landscaping. Over time, as organic waste is turned into manure by microorganisms, in landfills they cause the production of methane, so wet waste must be discarded separately.

1.4 Ferrous Metal- They are 100% recyclable and can be recycled countless times. The use of ferrous metal waste in steel production saves natural resources and more than 75% of the energy needed for steel production from iron ores.

1.5 Hazardous Waste– It includes all types of wastes that are combustible, toxic, eroding and reactive. These items can injure you as well as the environment and must be disposed of correctly.

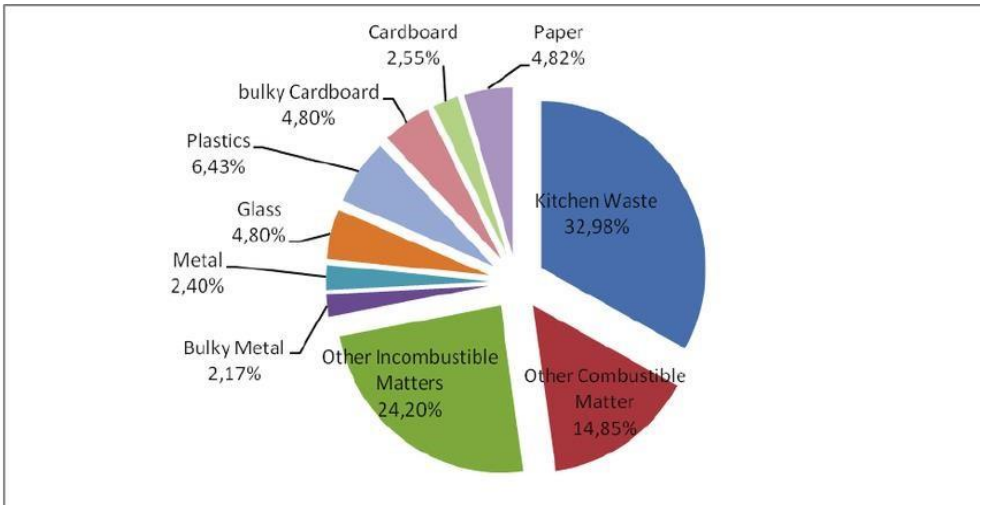


Fig.2 Source- https://www.researchgate.net/figure/Distribution-ofWasteTypes_fig4_285601246

2. Literature Survey

In [1], authors Rashi Kansara et al. It is the implementation of a smart garbage truck that can also segregate the waste inside the truck. Their system includes sensors such as ultrasonic sensors, gas sensors, IR sensor, RFID tags and infrared transmitter. As the truck keeps getting filled, the ultrasonic sensor keeps measuring the amount of garbage collected, as it reaches 80% of its capacity, a notification is sent to the driver and the lid of the truck closes. The gas sensor checks for any hazardous gas and if detected closes the lid until the waste is emptied. All the updates of the operations are sent to the servers using the GSM module. Inside the truck, the waste is segregated into dry waste, magnetic and general waste. The waste is first put on a conveyer and a blower blows out the dry waste and a magnet separates the metallic waste; the rest is put in the bin. Therefore, the smart garbage truck uses a host of components to make waste collection and segregation safer and use IoT to make waste management efficient.

In [2], authors Samarth Verma et al. have proposed a smart waste segregating bin with IoT. The system includes various sensors such as ultrasonic, magnetic sensor and moisture sensor. As waste is placed in the bin it starts segregating it on the basis of its magnetic properties using a magnetic sensor and moisture sensor to separate the wet and dry waste. This system can help in making waste management much more efficient and also make segregation much more widespread.

In [3], authors Shyamala S.C et al. have implemented IoT based system to make waste local waste management much more efficient using sensors like ultrasonic sensor and GSM module. They have proposed a smart bin that can alert the municipality or the local authority if a particular bin is about to be full. An ultrasonic filter will constantly monitor the level of trash filled in the bin and as the bin is about to be full, a notification will be sent. This is a very useful solution as it will drastically reduce overflowing bins which are a health hazard and severely impact the environment.

In [4], authors Santosh Kumar BR et al. have proposed a system in to segregate biodegradable waste from non-biodegradable waste and metallic waste using a smart dustbin. The dustbin will be equipped with a biodegradable unit that will have microbe sensors to detect biodegradable waste. It will also have a gas sensor as biodegradable waste is more prone to emit methane which is poisonous. It will also have inductive and capacitive sensors to segregate metal and plastic waste and dispose them in different segments of the dustbin. Once the dustbin is about to be filled, the wi-fi module will send a notification to the waste department.

In [5], Tejashree Kadus et al. have come up with an ingenious system to encourage people to throw the garbage in the bin rather than to just litter the trash outside. The system consists of load sensor, IR sensor and a wi-fi module. As someone puts garbage in the dustbin ; the load sensor will measure the trash and display how much weight is required. Once the weight is suitable, the dustbin opens and the public WIFI password is displayed. This system can be very useful by helping people it make a habit of throwing garbage in the dustbin by giving them the incentive to use free wi-fi.

3. Patent Survey

Patent number US20210188541A1: “Smart waste bin sensor device and methods for waste management system”[6]: A waste management system comprises a waste bin storing waste, wherein the waste bin comprises a smart waste bin sensor device installed on the waste bin of a waste bin owner. The smart waste bin sensor device comprises a set of sensors that sends and receives signals through a wireless network to a cloud server. The set of sensors implements, operates, detects, measures, and monitors environmental conditions inside or outside the waste bin. A waste and litter sensor detects, measures, and monitors a waste type, a waste volume, a litter type, a litter level, a biohazardous waste type, and a biohazardous waste level. A pathogen biosensor detects, measures, and monitors a pathogen type and a biosafety level. The pathogen biosensor comprises a sterilizer to kill pathogens. A waste bin mobile application and a waste collection facility application functionality enable a user to monitor waste in the waste bin.

Patent number ES2610421T3: "Smart Waste Collection System and Method" [7] - This patent describes a waste collection system that uses sensors and machine learning algorithms to optimize collection routes and schedules. Sensor system comprising a sensor device for remote monitoring of a waste container , the sensor device comprising: one or more sensors

for detecting the amount of waste and the environment within the waste container ; a data processing unit for processing sensor signals generated by the one or more sensors indicative of the amount of waste in the waste container and the environment within the container of waste; a communication interface coupled to the data processing unit to allow the sensor device to communicate information corresponding to the sensor signals to a remote location in relation to the sensor device ; and a power unit to power the sensor device ; characterized in that, the sensor system further comprises one or more separator elements , a heat reflective layer and a mounting arrangement for mounting the sensor device on the lower surface of an upper lid of the container of waste separately by placing the one or more separator elements in combination with the heat reflective layer disposed between the sensor device and the top cover of the waste container of such that a thermal barrier is provided between the bottom surface of the lid of the waste container and an external surface of the sensor device.

Patent number AU2019100273A4: "BinWin"[8] - BinWin is a modern-day waste collection technology enabling councils and waste management authorities to manage waste effectively. The framework consists of IoT, AI, mobile & web applications integrated to monitor, track, and plan. The bins ensure eco-friendliness by keeping a constant check on fill levels enabling waste collection on a needs basis preventing over-flow, maintaining a hygienic environment using solar self-charging capability. BinWin promises to increase operational efficiencies in the waste collection chain, reducing cost and labour associated with rubbish collection & removal.

4. Literature and Patent Gap

• The surveyed literature [1] has the following drawbacks:

1. It only considers the bins that are filled equal to if its level exceeds 80% of the bin or contains harmful gas.
2. If the trucks are overloaded, it discards its further route of collection.
3. Inadequate data about garbage collecting time and area of the bin.
4. Inadequate facility for monitoring the system, trail the truck and bins. There is no facility for quick response to critical cases like accident of the truck and breakdown.
5. No way for clients to complaint about bins being full if the bin system breaks down
6. It uses RFID card to indicate when it empties the bin. Every time the bin is emptied, the status of the bin is updated and to empty the bin, RFID card is used.

• This surveyed literature [2] has a disadvantage that some bin gets filled up much faster than the next scheduled time for collection which causes an overflow of waste.

• Unnecessary extra costs of more ultrasonic sensors and load cell do the same work [5]. Also, if the waste consists of metals and glasses, it will not be separated and mixed with the decomposable wastes.

•It may make people greedy and in turn would produce much more waste.

• Most of the proposed systems are quite complicated and the processing requirements are quite high.

- In all the systems all controlling units are all linked together which could cause complication and delay in signal can cause the system to be inefficient.
- The real world cost of implement these systems are very high and require a lot of capital.
- Segregation of waste by material on the basis of dielectric constant values is not very efficient, it doesn't distinguish plastic from cans.
- Smart systems that use deep learning in segregating need a lot of data to be trained
- Certain system cannot segregate ceramic waste from dry waste. Only one kind of waste is segregated at a time which is not efficient.

5. Problem Definition

Segregation of waste is the first and most important step in waste management and environmental preservation. It allows for better disposal of waste and encourages more recycling and reuse of matter. Lack of segregation is the root cause of clogged landfills, blocked drains, soil and water pollution and can hinder the entire process of waste disposal, recycling and reuse. To reduce the effort required to segregate waste, many cities and airports have employed bins with partitions for different types of waste. It has, however, failed to work, since users do not take the effort to dispose of the waste correctly. So we require a kind of a system that not just segregates the waste but it must also be less complicated, easy to set up and should be economically feasible for a country like India that suffers from improper waste management.

6. Detailed Methodology

6.1 Components Required

Arduino UNO

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

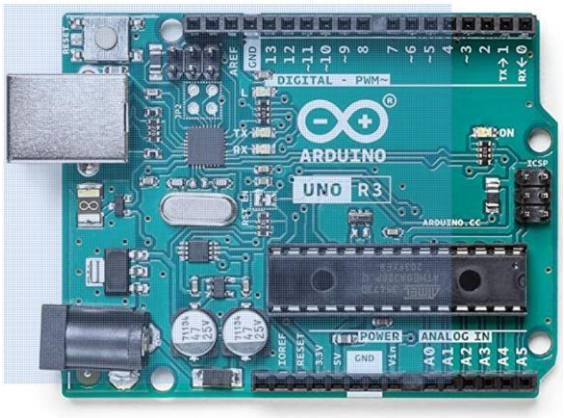


Fig. 3 Arduino UNO

SG-90 Servo Motor

Micro Servo Motor SG90 is a tiny and lightweight server motor with high output power. Servo can rotate approximately 180 degrees (90 in each direction), and works just like the standard kinds but smaller. You can use any servo code, hardware or library to control these servos.

Fig4. SG-90 Servo Motor

Ultrasonic Sensor

HC-SR04 is an ultrasonic ranging module that provides 2 cm to 400 cm non-contact measurement function. The ranging accuracy can reach to 3mm and effectual angle is < 15°. It can be powered from a 5V power supply. An ultrasonic sensor is a sensor that measures distances through ultrasound which travels through the air. If the ultrasound hits an object or obstacle on its path, it will then bounce back towards the sensor.

Fig 5. Ultrasonic Sensor

Soil Moisture Sensor

The Soil Moisture Sensor is a simple breakout for measuring the moisture in soil and similar materials. The soil moisture sensor is pretty straight forward to use. The two large exposed pads function as probes for the sensor, together acting as a variable resistor. The more water that is in the soil means the better the conductivity between the pads will be and will result in a lower resistance, and a higher SIG out.

To get the Soil Moisture Sensor functioning all you will need is to connect the VCC and GND pins to your Arduino-based device (or compatible development board) and you will receive a SIG out which will depend on the amount of water in the soil.

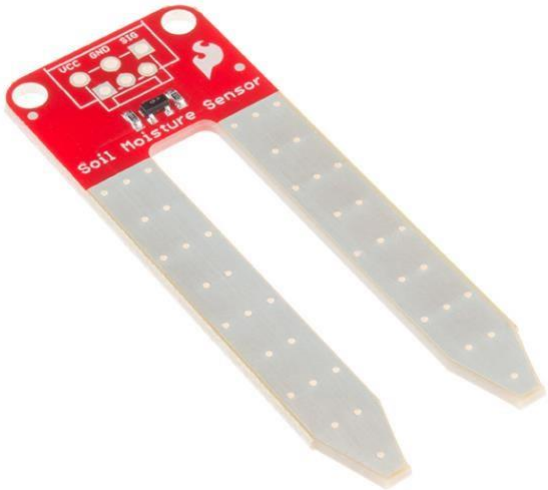


Fig 6. Soil Moisture Sensor

6.2 Methodology

For this project we are making a smart waste segregation system that is going to help in segregating household wet and dry waste from magnetic waste.

With the help of sensors, we can able to segregate the different wastes and promote the recycling and reuse of garbage.

We use ultrasonic sensors to sense the waste and measure the distance from the dustbin. The soil moisture is used to detect if the waste is dry or wet if the waste is dry the servo motor rotates such that the waste falls into the dry waste compartment.
If the waste is wet then the bin rotates to make the waste fall into the wet waste compartment.

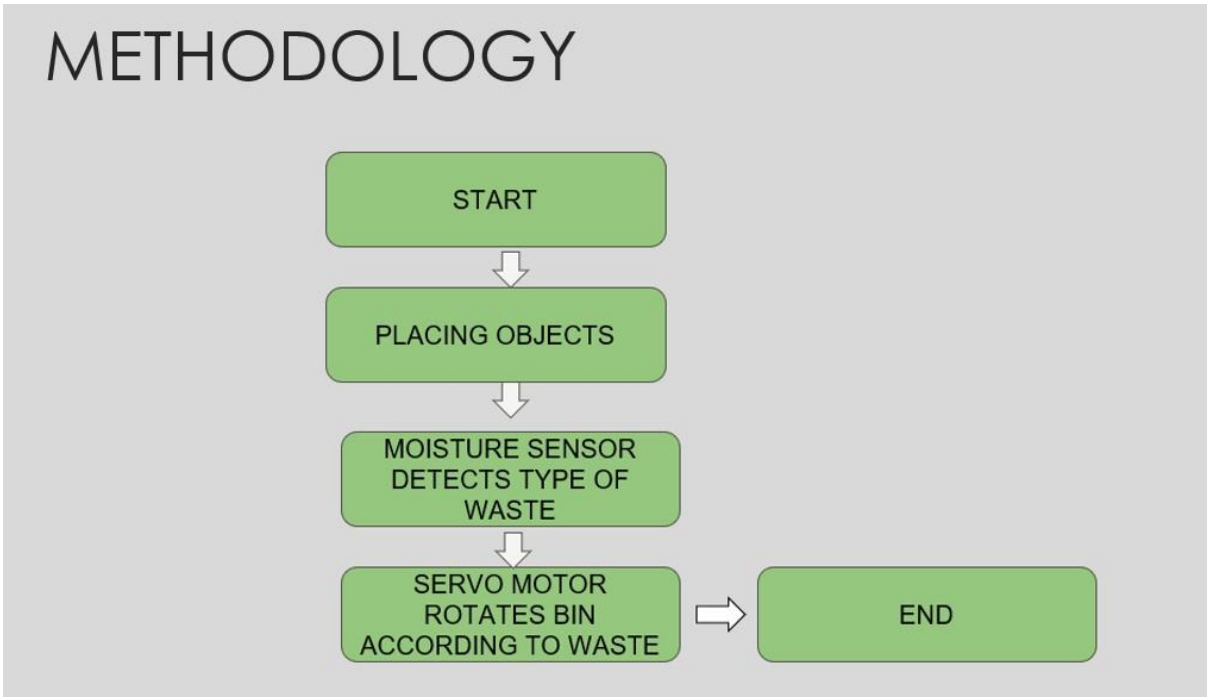


Fig. 7 Methodology

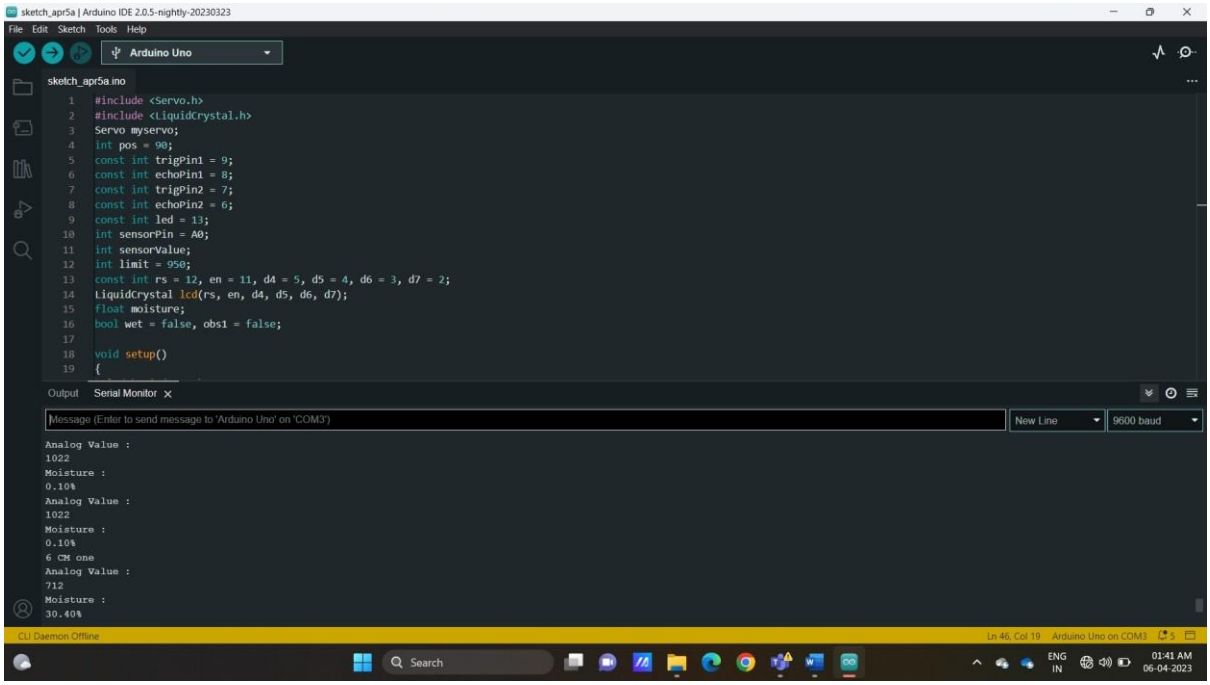
7. Constraints:

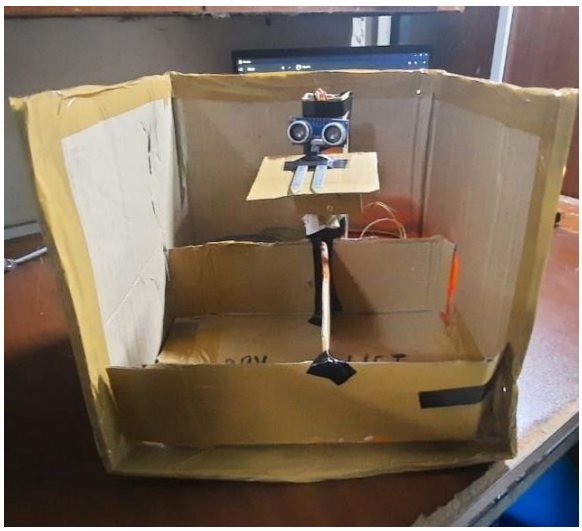
S.No.	Realistic Constraints in Design	Implemented (√) - Yes; (X) - No (N/A) - Not- Applicable	Comments (If any)
1	Economic	√	More investment is needed as the best quality components are expensive.
2	Environmental	√	Mixing of waste might affect land fertility and pose threat to the environment.
3	Social	X	
4	Political	X	
5	Ethical	√	Similar products exist in the market which are patent protected.
6	Health and Safety	√	The saturation of waste may cause serious health threats to both humans and animals.
7	Manufacturability	√	Mistakes in code programmed in the Arduino. Sensors may not detect effectively.
8	Sustainability	√	Often it may happen that dry wastes have high moisture content due to several environmental factors. In such cases, proper segregation may not happen.
9	Legality	X	

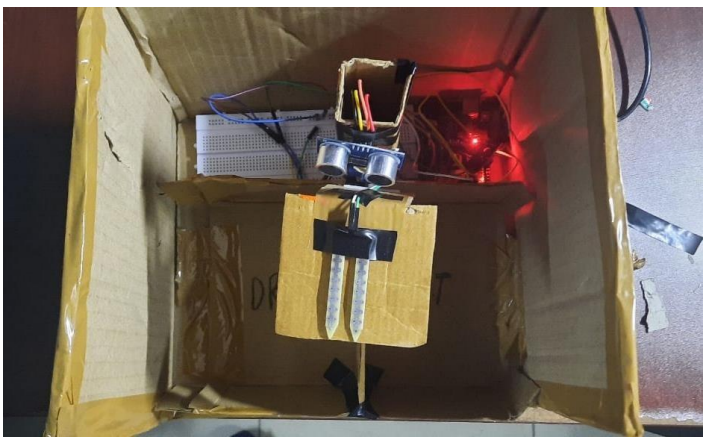
8. Results and Discussion

The above proposed approach eases the segregation of wastes at source level and thereby reducing the human interaction and curbs pollution caused by improper segregation and management of wastes at source level.

In most of the places, waste management is done manually. This increases more time to perform some task as well as manpower. Also, the work done is not perfect and the waste is not segregated to either reuse it or decompose it appropriately. When waste is not managed properly, it directly affects the human health as well as the nature. The waste when not managed properly creates environment pollution and makes people prone to diseases.







VIDEO LINK:

https://drive.google.com/file/d/1g2smUUdSSZAvaFueDJLBEAR5Tg09L2ei/view?usp=drivesdk

9. Project Outcome in terms of Technical, Economical, Social, Environmental, Political and Demographic Feasibility

The solution devised has technicalities in it due to which the solution is unique while being implementable. Thorough understanding of components , working, coding as well as design implementation is required. Knowing the connections to the various sensors such as Ultrasonic sensors and Soil Moisture sensor makes the solution easy to execute.

The person that designed and devised the solution would needed to have understood the working of Arduino UNO . He would be well versed about the various electrical components and how they would mutually assist the solution with implementation of the code.

Understanding the mechanical application of sensors and their interaction with respect electrical components shows that technical understanding , a student needs.

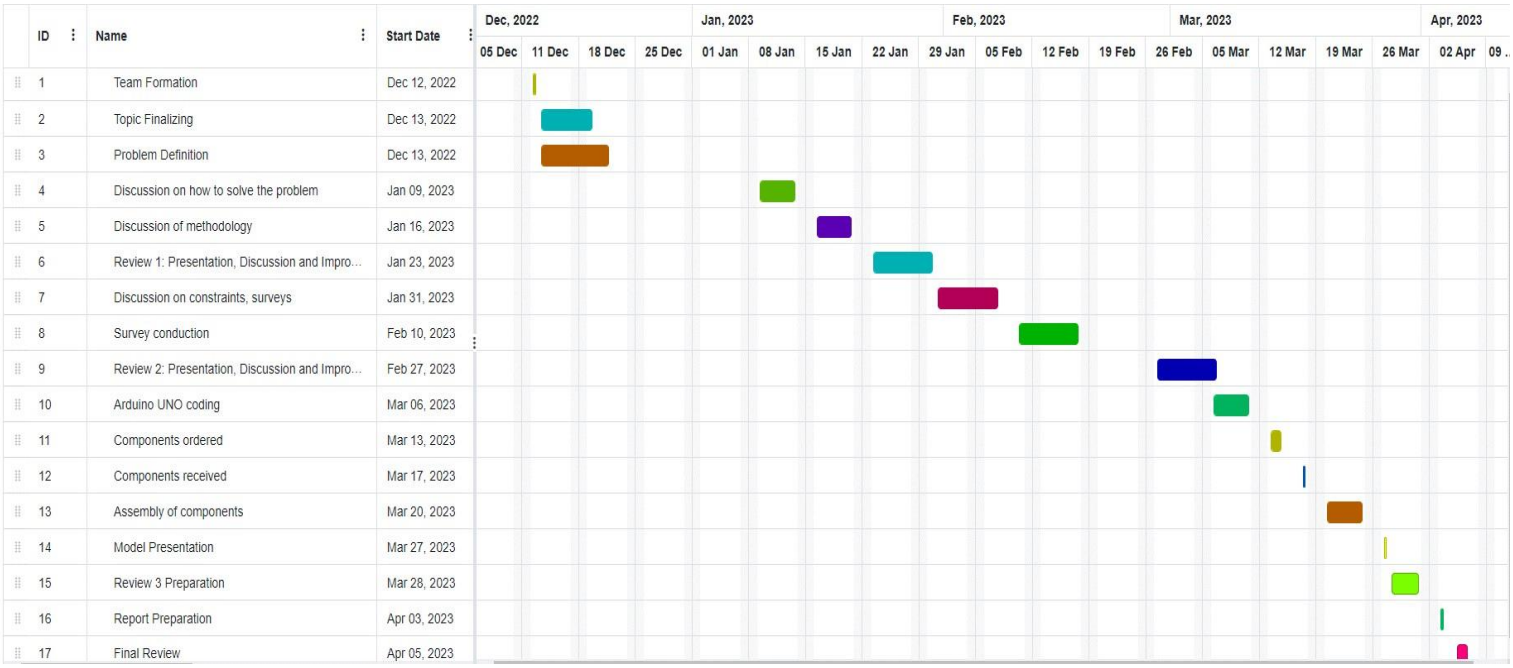
The solution formed is a very economical and cost saving mechanism. Industries in every sector need to follow waste disposable rules and regulations. Many industries are penalized in this regard. It is an issue which often goes unnoticed. Penalties often borne by Corporations is huge due to the amount of waste generated and in addition to lack of management of it. This adds another economic expense thus reiteration the fact that the solution must be implementable and cost saving.

Waste Management is an issue with respect to huge corporations as well as people in households. Proper caution must be taken as most often , the wastes are separated manually. It is extremely difficult and terrible task to perform. On a social ground, such tasks shouldn't be done by human or manually. Thus it gives rise to automation.

The wastes once separated in the early stages helps keeping the city clean and environment healthy. Most people that separate wastes are prone to deadly diseases like TB, Asthma, Skin diseases. Environmentally , it pollutes the soil as well surrounding, causing air , water and soil pollution. In addition ,the terrible odor makes this outcome a need.

The Waste management system can be applied in any part of the world irrespective of political or demographic feasibility. It can be implemented at homes , offices , industries and outdoors.

`10. Gantt Chart



ID	Name	Start Date
1	Team Formation	Dec 12, 2022
2	Topic Finalizing	Dec 13, 2022
3	Problem Definition	Dec 13, 2022
4	Discussion on how to solve the problem	Jan 09, 2023
5	Discussion of methodology	Jan 16, 2023
6	Review 1: Presentation, Discussion and Impro…	Jan 23, 2023
7	Discussion on constraints, surveys	Jan 31, 2023
8	Survey conduction	Feb 10, 2023
9	Review 2: Presentation, Discussion and Impro…	Feb 27, 2023
10	Arduino UNO coding	Mar 06, 2023
11	Components ordered	Mar 13, 2023
12	Components received	Mar 17, 2023
13	Assembly of components	Mar 20, 2023
14	Model Presentation	Mar 27, 2023
15	Review 3 Preparation	Mar 28, 2023
16	Report Preparation	Apr 03, 2023
17	Final Review	Apr 05, 2023

11.References

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[7] "Smart Waste Collection System and Method" by Fredrik Kekalainen and Enevo Oy

[8] "BinWin" by Kasim Raza Rajani