# Smart Waste Monitoring System using IoT

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***Abstract :*** Waste Management can be defined as the management of waste from its inception to its disposal. This project deals with the problem of waste management in urban areas where the waste management process is not efficient. The main aim of the project is to automate the waste managing process, smartly, using the Internet of Things. In the proposed system, we aim to measure the fill level of dry and wet dustbin and send a notification to the garbage collector if the fill level exceeds 75% mark. We have also provided a data monitoring feature. The ultrasonic sensors measure the bin level and the result is displayed on the serial monitor of Arduino IDE, this result is also stored in a Thingspeak channel and the alert notification is sent using IFTTT service. The NodeMCU module is used to connect to the internet and Arduino UNO is used for interfacing purpose.

***IndexTerms*** **– Waste Monitoring System, Arduino UNO, NodeMCU, Ultrasonic sensor, IFTTT, ThingSpeak**

## I. INTRODUCTION

Waste management is the method of efficiently managing waste from its formation to its disposal. A safe and sanitary environment is essential for the overall health of the community; some waste can be harmful to human health. Every day, the amount of waste generated around the world is growing. Waste management is a crucial problem as with the growing population, the generation of municipal solid waste also increases. An article [1] shows that the world generates 2.01 billion tonnes of waste annually out of which at least 33% of waste is not handled in an environmentally safe way. The countries having high income generate about 683 million tonnes of waste annually. It is estimated that by the year 2050, the waste generated will reach 3.40 billion tonnes mark. Another study [2] shows that urban India produces about 62 million tonnes of waste and it is estimated that, by the year 2030, it will reach the 162 million tonnes mark. 31 million tonnes municipal solid waste out of collected 43 million tonnes are dumped in landfills and only 11.9 million tonnes waste is treated. These numbers are highly alarming and we can clearly see that waste management is an important issue at hand.

Waste management requires a lot of human efforts, also the regular monitoring trips done by the municipal workers result in consumption of fuel and worker's time, these resources can be saved if we automate the waste management process. By automating the waste management process, workers can be sent to those areas only where the fill collection is required, this helps in conservation of fuel. The proposed system helps to achieve the above problem. Along with it, different types of waste, domestic- dry and wet, industrial, hospital wastes, can be collected efficiently by using our system. Speaking of hospital waste, there has been a spike in the generation of medical waste due to the COVID-19 pandemic and proper disposal of this waste is very essential as the virus can also transmit through this waste. The proposed system can help the collectors to know the fill level of each garbage bin in a locality or city at all time, to give a cost effective and time saving route to the truck drivers and collect the surgical waste effectively.

In this paper, Related Work is mentioned in Section 2. The methodology, requirements and process are explained in section 3 and 4 respectively. Advantages and applications are discussed in section 5. The results are discussed in section 6 and conclusion and future scope are mentioned in section 7.

## II. RELATED WORK

S. Paul et al. [3] smart garbage monitoring system using IoT based on Arduino UNO which monitors the bin level and segregated biodegradable and non-biodegradable waste. The system uses ultrasonic sensor to measure the bin level in the dustbin. A servo motor is used to segregate the bio-degradable and non-biodegradable waste by moving the waste left and right. A RC-A-524 Metal Detector Sensor Module is used to detect whether the waste is metallic or not. If waste has metallic content, it is marked non-biodegradable, otherwise it is marked biodegradable. Two IR sensors are used. First IR sensor is placed on the top of the bin which detects the waste and activates the metal detector. Second IR sensor is placed at the bottom of the bin which checks if the garbage has been kept outside the bin. An OV7670 image sensor collects the image data and a Computer Vision API is used to check whether the waste is an objectionable item or not. All these sensors and circuits are interfaced with Arduino UNO. ESP8266 WiFi module is connected to the system which grants WiFi access to the system. This monitoring also has an alert system for certain wastes such as bombs or weapons.

A. G. Azwar [4] proposed a smart trash monitoring system design using NodeMCU. This system uses ultrasonic sensors, two LEDs and NodeMCU. The ultrasonic sensor is used to measure the distance and find the fill level of the bin. A red and a green LED is used to check whether bin is full or not. If bin is empty, green LED is turned on and if the bin is full then red LED is turned on. NodeMCU is used to interface all the LEDs and the ultrasonic sensor. It also connects to the WiFi network which is used to store data on server. The data from the sensors is published to the cloud server with the MQTT protocol. Using AJAX and PHP programming technologies, the web application's data subscription results are then stored in a database server. This data is then displayed on a dashboard which can be accessed using any browser.

J. Das [5] proposed a smart garbage monitoring and alert system using IoT. This system uses NodeMCU, DHT-11 sensor, HC-SR04 Ultrasonic sensor, and MQ4 sensor. The NodeMCU interfaces all the sensors and connects to the WiFi. The DHT-11 sensor measures the temperature and humidity which is used to segregate dry and wet waste based upon the output of the sensor. The ultrasonic sensor is used to calculate the fill level of the garbage in the bin. The MQ4 sensor measures methane and natural gas which is used to measure the odour of the garbage. The system also uses an android application which monitors the data in real-time. One has to login with valid user id and password on the application so that only authorised person can access the data. IFTTT (If This Then That) service is used for the notification service. If the threshold is crossed then an SMS or email notification is received by the authorised person.

Chen et. al. [6] proposed a Smart Waste Management System that uses a microcontroller unit along with infrared sensor, gas sensor and a 3-axis compass. The microcontroller unit is used as an interface between the sensors and the server. The infrared sensor and gas sensor are used to determine the fill level and the smell level of the dustbin respectively. The readings from these sensors are sent to the server via WiFi module in indoor settings and Long Range module (LoRa) in outdoor settings. The data sent to server is then stored into a MySQL database by the Data manager. The data is monitored periodically by the alert function and when the fill level of dustbins cross the threshold level, a notification function is evoked which sends the notification to the truck driver along with route that is created using Google Maps.

Adam et. al. [7] proposed a Waste Management System using IoT and wireless sensor network. The main components of this system are Arduino UNO, Ultrasonic sensor and ESP8266 Wi-fi module. The ultrasonic sensor determines the garbage level in the garbage bins. The data from the sensor is read by the Arduino UNO and then the microcontroller sends the data to the server via ESP8266 Wi-Fi module. The data is displayed on a web page as well as stored in a database. According to the level of garbage (empty, half and full) the dustbins are displayed on the web page along with the location. A message is sent to the truck driver if the fill level in the dustbin is full.

Kumar et. al. [8] proposed an alert system based on IoT for regular garbage clearance that alerts the web server to collect the garbage by sending an alert signal. The smart dustbins are built in such a way that they consist of a compressing plate which allows higher degree of garbage dumping than usual. The dustbin has a leaf switch which is placed a little lower than the maximum level. The dustbin is designed in such a way that the functionality of the leaf switch is never disturbed. This system makes use of an ultrasonic sensor for determining the garbage level in the dustbin, Arduino UNO is the microcontroller unit used and the sensor readings are sent to the Thing Speak server via ESP8266 Wi-Fi module. An RFID tag is used for verification of the garbage clearance by interrupting the RFID reader which makes ultrasonic sensor to check the garbage level and update the web server. They have also created an Android application that is linked to the Things Speak server and receive notifications.

## III. METHODOLOGY.

As seen in the figure 1, the ultrasonic sensors are connected to the Arduino. The first ultrasonic sensor is for dry waste and the second ultrasonic sensor is for wet waste. Both the sensors emit soundwaves and return the time of time distance travelled in microseconds. By using a formula we calculate the distance in centimeters. We use this distance to calculate the percentage of fill level.

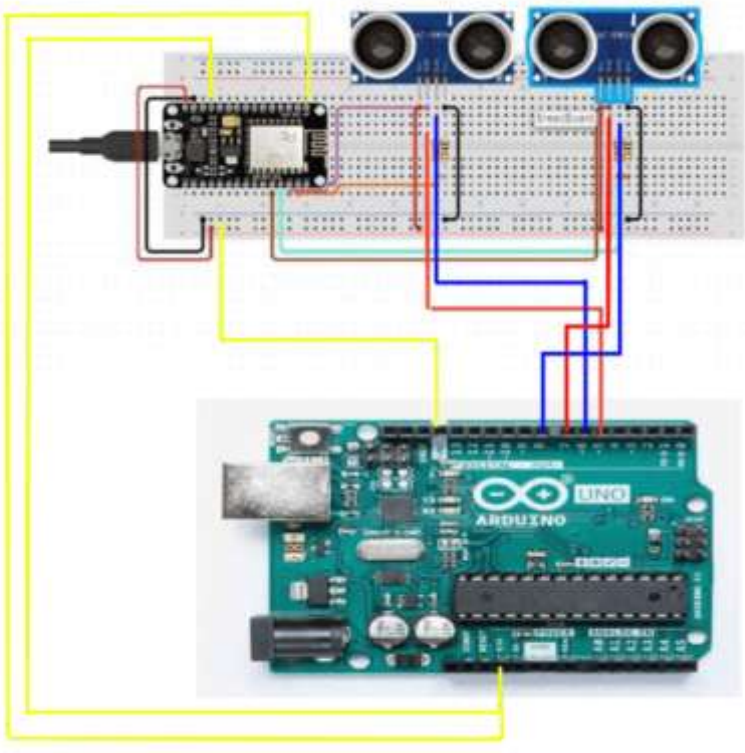



Figure 1: Circuit Diagram of Smart Waste Monitoring System

The NodeMCU is used to connect to the WiFi and send data to the server continuously. If the client connects to the server we start sending data with the help of the API key of the ThingSpeak channel. This process works on a loop every ten minutes.

When the percentage value is greater than 75%, a trigger is created in IFTTT and a notification is sent on the IFTTT application along with a location link of the dustbin.

When the percentage is lower than 75%, the program will still go but no trigger will be created. However, the data can be monitored on ThingSpeak channel. So, if the garbage has not been collected from a place for a long time it can be seen on the channel and a garbage collector can be assigned to that place.

## IV. REQUIREMENTS AND PROCESS

### 4.1 Hardware Requirements

Following hardware components are the system:

#### 4.1.1 Ultrasonic Sensor

The supply voltage of the ultrasonic sensor is 5V. Its global current consumption is 15mA. It has a frequency of 50 kHz. It ranges between 3 cm and 400 cm. It has a resolution of 1 cm. Its trigger pulse width is 10us.


Figure 2: Ultrasonic Sensors

The figure 2 a) and b) show the ultrasonic sensor.We have used ultrasonic sensors because it works using sound waves and detecting obstacles is not affected by as many factors. Therefore, it is more reliable than other sensors like IR sensors.

#### 4.1.2 NodeMCU

NodeMCU contains Tensilica 32-bit RISC CPU Xtensa LX106 microcontroller. It's operating voltage is 3.3V. It's input voltage varies from 7 to 12V. It has 16 digital I/O pins and 1 analog input pin. It also has 1 Universal asynchronous receiver-transmitter (UART). It has a flash memory of 4MB and SRAM of 64KB. It has a clock speed of 80 MHz.

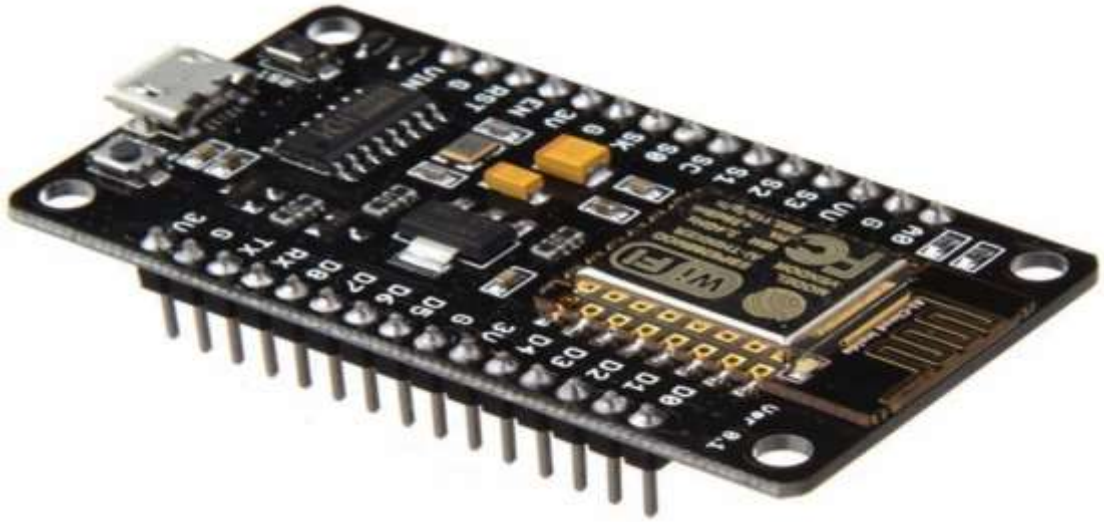


Figure 3: NodeMCU

Figure 3 shows the NodeMCU component. The NodeMCU is a low-cost, very user-friendly device that offers Internet access. The module can act both as an access point (can create a hotspot) and as a station (can connect to Wi-Fi), so it can quickly download data and upload it to the internet making it as convenient as possible for the Internet of Things.

#### 4.1.3 Arduino UNO

Arduino UNO contains Microchip ATmega328P microcontroller. It's operating voltage is 5 volts. The input voltage ranges from 7 to 20 volts. It has 14 digital I/O pins and 6 analog input pins. The DC current per I/O pin is 20mA and DC current for 3.3V pin

is 50mA. It has a flash memory of 32KB, SRAM of 2KB and EEPROM of 1KB. It has a clock speed of 16MHz.


Figure 4: Arduino UNO

Figure 4 shows the Arduino UNO component. This system uses Arduino UNO as it is the most standard arduino board available. Its biggest advantage is that we connect the board to the computer via a USB cable which does a dual purpose of supplying power and acting as a Serial port to interface the Arduino and the computer. It can also be powered by a 9V-12V AC to DC adapter. It is easy to use and best suited for beginners.

**4.2 Software Requirements**

Following softwares were used in the system:

**4.2.1 Arduino IDE**

Arduino Integrated Development Environment (IDE) includes a text editor for writing code, a text field, a console, a basic feature button toolbar and a set of menus. To import programmes and work with them it interfaces to the Arduino hardware. The system requirements are Microsoft Windows 8/8.1 or Windows 10 operating system , Intel Pentium / AMD Athlon processor or equivalent running at 1 GHz or more and 512 MB RAM (1 GB RAM recommended).

**4.2.2 Tinkercad**

Tinkercad is an online compilation of Autodesk software resources that allows complete novice to produce three - dimensional components of circuits. It offers circuit modelling facilities as well. The circuit segment integrates the circuitry, programming and serial display components. Browsers that work best with Tinkercad are Google Chrome 10 (or newer) and Mozilla FireFox 4 (or newer). Operating Systems that are known to work well with Tinkercad, are Microsoft Windows 7 or later, Apple OS X 10.6 or later and Google Chrome OS on Chromebooks.

**4.2.3 ThingSpeak**

ThingSpeak is an open-source Internet of Things programme and API that stores and retrieves information from objects over the Internet or via a local area network using the HTTP and MQTT protocols. ThingSpeak incorporates support from MathWorks' MATLAB numerical computing tools, enabling users of ThingSpeak to evaluate and simulate uploaded data using Matlab. The system requirements are current version of Google Chrome, Internet Explorer, Internet Explorer, Mozilla Firefox, Microsoft Edge and Safari.

**4.2.4 IFTTT**

If This Then It is a web-based application that enables users to build links of conditional statements triggered by other web services such as notifications of IFTTT, email services like gmail or social media services like facebook, twitter etc. The web application works on any browser. The app works on Android 4.4 or later and iOS 10 or later.

**4.3 Process**

This project uses two ultrasonic sensors to calculate distance. Ultrasonic sensors emit ultrasonic sound waves and return digital signal. By using the formula for the centimeter of ultrasonic sensor, we calculate the centimeter distance of the fill level. Then we use map function to calculate the percentage of the same. This Ultrasonic sensor is connected to Arduino UNO. With the help of Arduino UNO, we can see the fill level on the serial monitor of Arduino IDE. The NodeMCU connects to the wifi and writes to the ThingSpeak channel. The ThingSpeak channel contains two fields, one for the percentage of wet waste and one for the percentage of dry waste. With the help of WifiClient library of Arduino IDE, both percentages are sent as data to the ThingSpeak server. The ThingSpeak server is integrated with IFTTT service. A trigger is created using the webhooks service of IFTTT to receive a web request. After that notification service is used to create action. Then a ThingHTTP is created using the webhooks url which is followed by creating a React in Thingspeak to the data. Here the condition is applied to send notification when either of the dustbins cross the 75% threshold. The garbage collector receives this notification on their IFTTT app along with the link of location of the bins.

## V. ADVANTAGES AND APPLICATIONS.

### 5.1 Advantages

This system has several advantages. It can be monitored remotely from anywhere on ThingSpeak. One can also see the previous as it is being stored on ThingSpeak server. It also saves fuel as the garbage collector only has to collect garbage when the bin is full. It also saves time of the collector as they don't have to check for garbage every time.

### 5.2 Applications

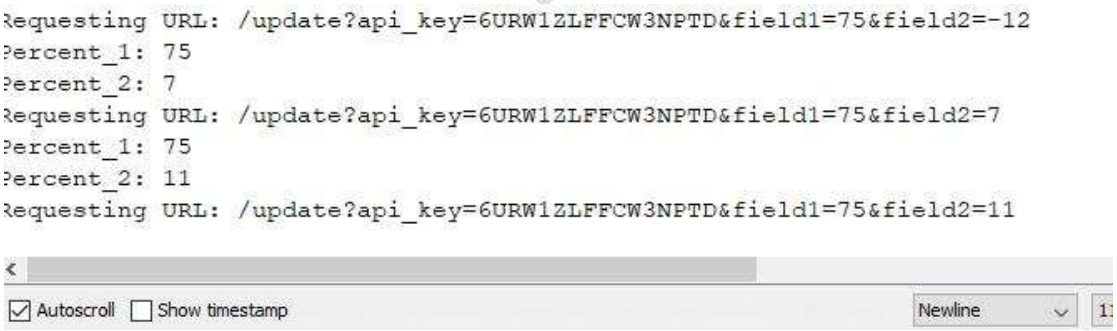
This system can be used in any place that has a good internet connection. The system can be placed on the top of the garbage bin of any area of the city and the bin levels can be monitored by the municipal corporation or any other organization responsible for garbage collection of that area.

## VI. RESULTS

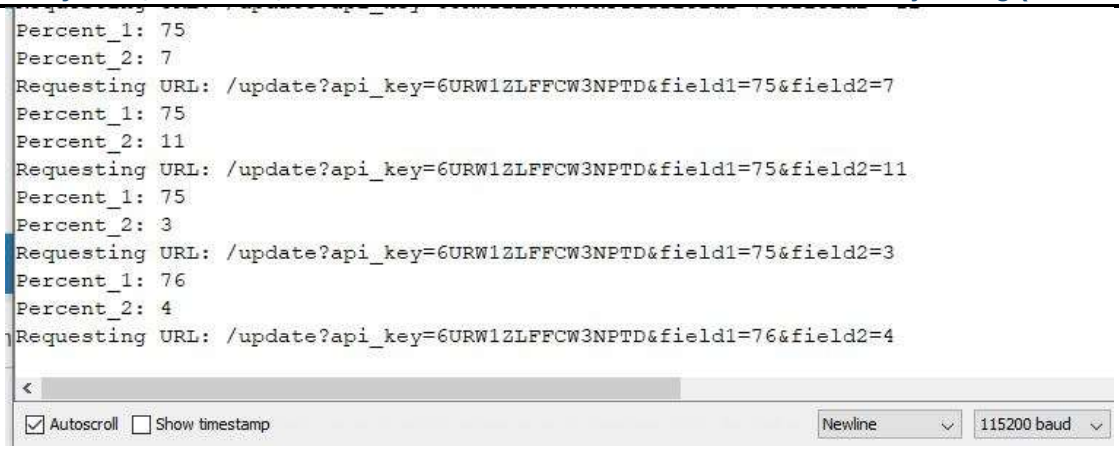
The setup of the hardware part of the project is shown in figure 5. The ultrasonic sensors are attached to both the dustbins and they are connected to the Arduino. The NodeMCU connects to the Wifi when the Arduino UNO connects to the laptop and the code gets uploaded.


Figure 5: The setup of Smart Waste Management System

Figure 6 a) and b) figures are snapshots of the serial monitor. The url for writing data to ThingSpeak and the time-to-time percentage of the fill level of both dustbins are displayed on the monitor.




a)




b)

Figure 6: Screenshots of Arduino IDE serial monitor

Figure 7 shows the snapshot of the ThingSpeak channel. This channel contains two fields. Field 1 is for dustbin 1 and Field 2 is for dustbin 2. As seen in the figure, visuals are automatically made by ThingSpeak and one can have the graphical representation as well. Moreover, one can also download csv, xml or json file to monitor the bins. Anyone who has access to the channel can monitor the fill level anywhere and anytime.

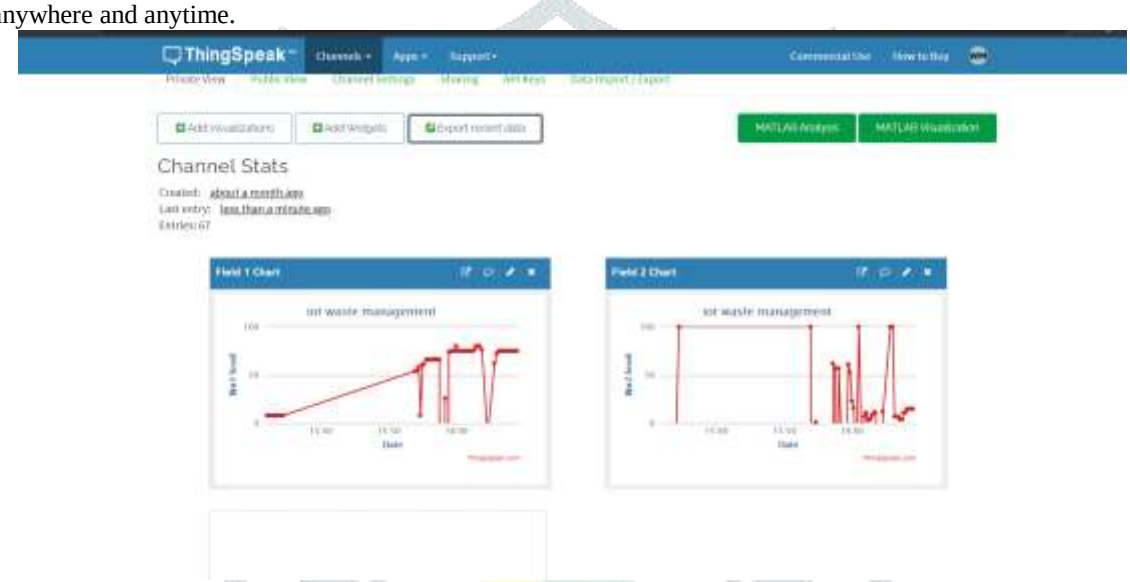
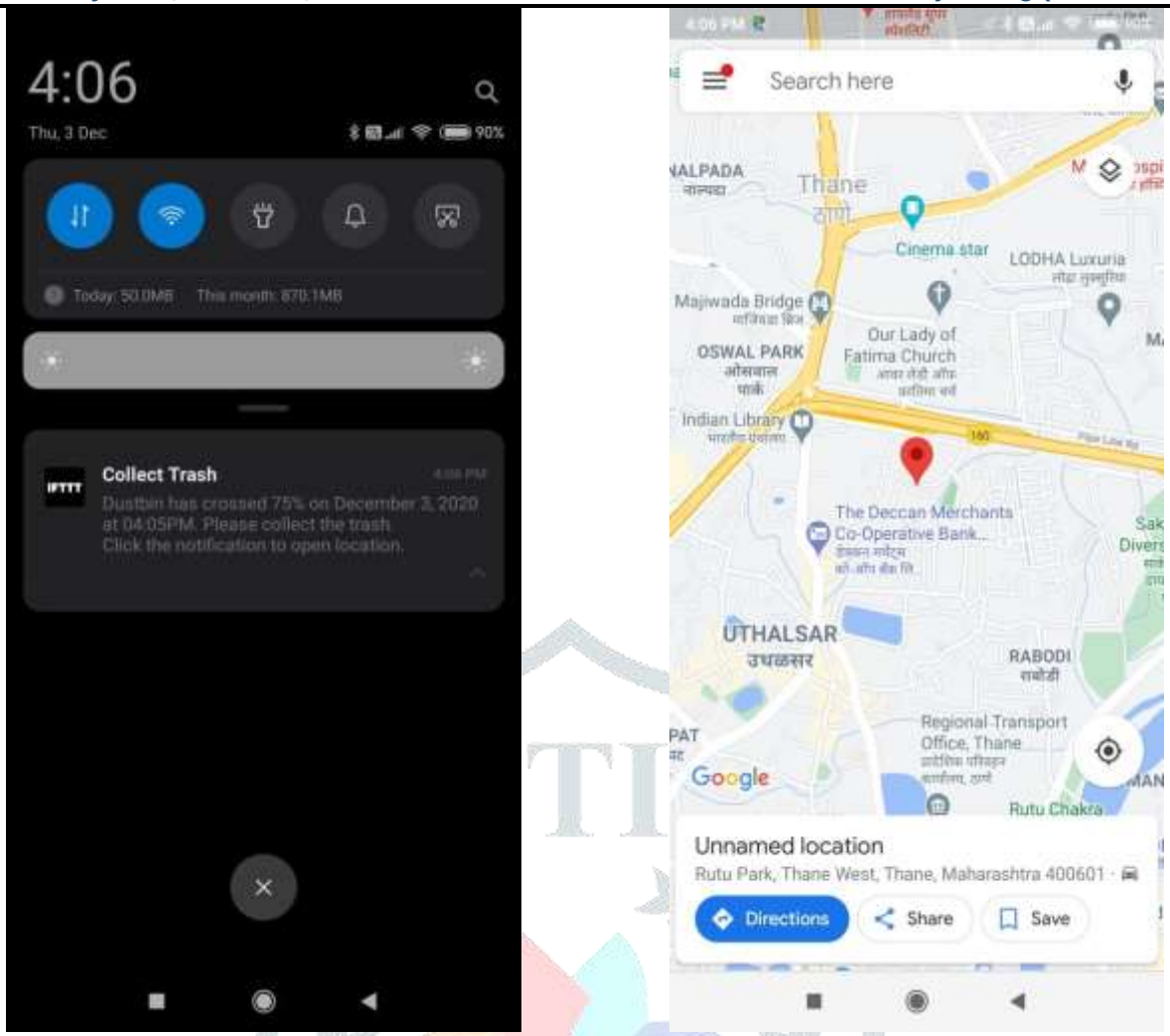



Figure 7: Snapshot of ThingSpeak channel

Figure 8 a) and b) snapshots show the notification when the bin level crosses 75%. The notification contains a message depicting that 75% threshold has been crossed along with date and time. And when the user clicks on the notification, it opens the location in GoogleMaps.




a) b)

Figure 8

## VII. CONCLUSION AND FUTURE SCOPE

As we have seen the intensity of the waste management problem, the proposed system is designed to help overcome the limitations of the systems that are available. We have successfully achieved the objectives like measuring the fill level of the dry and wet dustbins, monitoring the fill level in dustbins on ThingSpeak, and to send an alert message along with the location of the bin to the truck driver using IFTTT service. We are going to design a feature which sends an alert message to the truck driver for collecting the fill from dustbins having fill level below the threshold fill level i.e. 75%. Also, since this was the testing phase, we have used an uniform location, we are planning to add a feature that sends the location according to where the bin is located and test the proposed system for multiple bins.

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