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INTELLIGENT WASTE BIN MONITORING AND ALERT SYSTEM USING IOT TECHNOLOGY

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Abstract – *Waste monitoring is a critical aspect of urban infrastructure, affecting public health, environmental sustainability, and overall quality of life. These techniques are frequently inefficient, leading to problems like overflowing bins, unsightly litter, and increased operational costs. To address these issues, an Intelligent waste bin monitoring and alert system using IOT technology leverages cutting-edge technology to optimize waste collection. A Smart-Waste Monitoring Process development marks a notable progression in the way cities and municipalities handle waste. By leveraging sensor technology, data analytics, and proactive maintenance, this technique not only encourage the efficiency and cost-effectiveness of managing waste but also contributes to a cleaner and more sustainable urban environment. It enhances the residents' standard of living and supports global efforts to reduce waste and its environmental impact*.

Key Words: Smart Waste Monitoring System (SWMS/SWM), Dustbin level, Ultrasonic sensor, Internet of things (IOT), Moisture level sensor, Microcontroller, GSM/GPRS module.

1. INTRODUCTION

Handling Waste is an integral facet of modern urban life, influencing the health, aesthetics, and cleanliness of our cities and communities. The ever-increasing difficulties associated with waste collection, disposal, and environmental impact demand innovative solutions. In this context, the rise of SWMSs represents promising technological revolution that promises to addresses challenges effectively.

Traditional waste monitoring practices often suffer from inefficiencies, high operational costs, and environmental consequences. Overflowing trash bins, irregular collection schedules, and excessive fuel consumption by collection vehicles are common issues in many urban areas. Moreover, as the global population continues to concentrate in cities, the demand for efficient and sustainable waste monitoring becomes more pressing than ever.

SWMS utilize cutting-edge innovations like sensor networks, data analysis techniques, and real-time monitoring to optimize waste collection processes. These techniques not only encourage the efficiency of waste collection it also plays a role to reducing the environmental footprint and improving the quality of life in urban environments.

SWMSs are not merely a technological novelty; they represent a crucial step forward in urban infrastructure management. As our community's grapple with the increasing demands of urbanization and environmental stewardship, understanding and embracing this paradigm shift in waste monitoring is essential. This report aims to shed light on the transformative potential of SWMS and inspire stakeholders to consider its adoption for the betterment of our cities and the planet as a whole. Develop a SWMS that optimizes waste by leveraging IoT technology and data analytics to reduce operational costs, enhance environmental sustainability, and improve overall urban cleanliness. Inefficient gathering and overseeing waste items processes lead to increased environmental pollution, resource wastage, and high operational costs. To address this, there is a pressing need for a SWMS that leverages technology, such as sensors and data analytics, to streamline waste collection routes, reduce environmental impact, and improve overall efficiency in handling waste.

2. MOTIVATION

The motivation for adopting Smart Waste Monitoring lies in the urgent need to enhance the efficiency, cost-effectiveness, and sustainability of waste processes in our increasingly urbanized world. It aims to address overflowing bins, reduce operational costs, lower environmental impact, and improve overall urban quality of life.

3. RELATED WORKS

[1] As per the research conducted by Mohinish Paturi and colleagues in their paper titled "Innovative Approach to Solid Waste Management: Leveraging Blockchain and IoT for Smart Urban Areas," the innovated methodology advocates for a decentralized distribution system. This approach incorporates blockchain technology and smart contracts to motivate individuals towards effective waste segregation from the outset. Through the overcome of smart contracts, the system efficiently distributes rewards in a prompt manner. Notably, the proposed model demonstrates satisfactory operational speed when deployed on the Matic network, simultaneously reducing transaction fees.

[2] In the work authored by P Haribabu and team, they introduced a smart dustbin through the application of IoT in their publication titled "IoT-enabled Implementation of a SWMS". The implementation involved the utilization of an Arduino board, a GSM modem, and integration of an Ultrasonic sensor (HC-SR04) into the dustbin. Additionally, the dustbin was equipped with a buzzer and Light Emitting Diodes (LEDs) to visually indicate the levels of dust exists in the bin

[3] In research project titled "Smart_Garbage Monitoring System on Cloud Computing" by Jetendra Joshi and collaborators, they have devised a method employing cloud computing for efficient garbage monitoring. The project incorporates an ultrasonic sensor to gauge the dustbin's fill level. Moreover, an accompanying mobile application offers the user the most efficient route to the dustbin. Notably, their methodology is grounded in the Stack-Based Front-End approach. The authors elaborate on the potential application of machine learning techniques, specifically highlighting a Decision Forest Regression model to augment the overall performance of system.

[4] In the study conducted by Righa Tandon and colleagues titled "Harnessing the Capabilities of IoT for Sustainable Solutions in Waste Management," the authors propose the integration of IoT devices, sensors, and networks into waste management systems. This integration, they argue, provides the capability for real-time monitoring, tracking, and control throughout the entire waste management lifecycle, encompassing generation, collection, transportation, and disposal processes. Despite the promising advantages, the paper acknowledges persistent challenges that require attention. These include addressing the high costs with implementing IoT-based waste management systems, ensuring the establishment of reliable and secure communication networks, and overcoming the absence of standardized protocols and regulations in this domain.

[5] In the project titled "An Autonomous Smart Waste Collection System" presented by Shujatullah Khan and team, the authors introduced a comprehensive approach utilizing various communication modules such as Wi-Fi, Bluetooth, Zigbee, and an additional module. Their innovative smart dustbin incorporates Infra-Red (IR) sensors for operation. A GSM modem is employed to transmit data to the relevant rights when the waste reaches a predefined threshold level. Notably, the system records data during the waste collection process, and a machine learning algorithm is applied to analyze and calculate the locations where the highest amounts of trash were collected and the specific times at which this occurred.

[6] In the study conducted by Krishna_Nirde and colleagues titled "An IoT-based Solid_Waste Management_System for Smart Cities," the researchers put forward a concept emphasizing real-time monitoring of dustbins through two distinct sensing systems: waste-filled level sensing and weight sensing. The proposed system involves sending notifications when the dustbin reaches full capacity. However, the authors note that while weight sensing was considered, it may not be the most accurately predicting whether a dustbin is full or not. This observation suggests the requirement for further exploration and evaluation of sensing techniques to enhance the reliability and precision of real-time monitoring in solid-waste management systems.

[7] The project titled "Smart_Garbage Monitoring and Clearance_System leveraging the IoT," presented by S. Vinoth Kumar and team, introduced a commendable idea for efficient waste management. However, a limitation was identified in their approach as they faced challenges in predicting the moisture level, accountable for the unpleasant odor emitted from the dustbin. The system implemented sensors to accurately indicate whether the bins were filled or empty. Despite this successful aspect, the inability to forecast moisture levels highlights a potential area for improvement in addressing comprehensive waste management concerns.

[8] In the paper conducted by Imtiaz A and collaborators, focusing on "Dissipation of garbage using Dynamic_Perception and Alarming System: A Smart City Application," the researchers devised an Android-based application. This innovative application enables users to efficiently identify nearby dustbin locations, providing navigational paths on OpenStreetMap (OSM). This dynamic_perception and alarming system contribute to enhancing managing waste in smart cities, offering a user-friendly and accessible solution for individuals to locate and utilize nearby dustbins effectively.

[9] In the publication titled "An IoT-Enabled Solid Waste Management System in the Context of Indian Smart Cities" authored by Pooja Devi and team, the researchers introduced a system outcome utilizing a Wi-Fi enabled module. This module is designed to collect data from interfaced sensors, allowing relevant authorities to access the real-time status of the waste bins through the Adafruit cloud. Furthermore, the system provides continuous monitoring of air quality, humidity, and temperature in the surrounding area, offering a comprehensive approach to waste management that encompasses environmental factors for a more holistic solution.

[10] In the project titled "Smart City Initiative: Traffic and Waste Management" presented by Ankitha S and collaborators, the authors introduced an innovative approach that involves the utilization of smart dustbins, each assigned a unique ID number. Upon reaching full capacity, these smart dustbins trigger the transmission of a message to a central server. This server acts as a hub connecting all the garbage collection vehicles. The system ensures an

efficient waste management strategy by enabling timely responses from the connected vehicles to address the filled dustbins, contributing to the overall smart city initiative for improved traffic and waste management.

4. PROPOSED METHODOLOGY

The proposed SWMS leverages advanced technology to enhance waste collection in urban environments. It comprises IoT sensors installed in waste bins to monitor fill levels and transmit real-time data to a central server. Data analytics are employed to predict when bins are nearing capacity. The system focuses on reducing operational costs, carbon emissions, and improving overall environmental sustainability while engaging the public in waste reduction efforts.

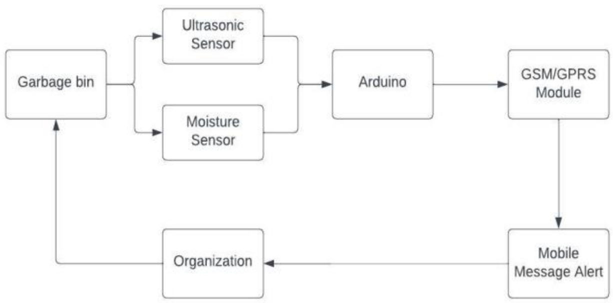

Fig. 4.1: Block-diagram of proposed-system

This project outlines the procedural steps necessary for implementing the proposed SWMS and identifies the essential hardware components required. The SWMS will utilize an ultrasonic range sensor to measure the quantity of garbage accumulated in waste containers. Subsequently, this data will be transmitted via a GSM SIM800L module to designated phone numbers registered at Waste Management Centers (WMC). To oversee this process, a microcontroller will be employed for control and coordination purposes.

The designated contact numbers registered at Waste Management Centers (WMCs) will receive real-time SMS notifications via the GSM module, displaying the fill levels of individual garbage bins on their phone screens. Oftentimes, even when a dustbin isn't fully occupied, it may emit unpleasant odors of wet waste, leading to unpleasant smells permeating the locality or city. To address this issue, a moisture sensor is installed within the dustbin to detect and mitigate the accumulation of wet waste, thereby helping to alleviate odor-related concerns.

The moisture sensor is designed to detect the moisture levels within the waste. If the moisture content exceeds a predetermined threshold level, the sensor transmits this information to the designated contact number at the waste management center. Upon receiving the SMS notification, prompt action is taken to address the issue with the respective dustbin, even if it is not at full capacity. This proactive approach effectively prevents the emergence of unpleasant odors emanating from the garbage bin, thereby preserving the cleanliness and ambiance of the locality or city.

The implemented system can also be understood using flow chart below in **Fig4.2.**

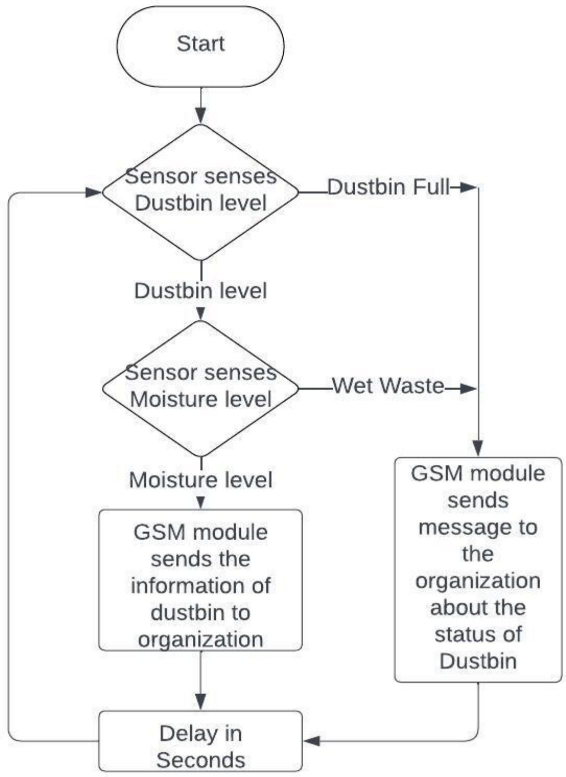

Fig. 4.2: Flow chart of proposed-system

1. Ultrasonic sensor senses the filling level of dustbin.
2. Moisture sensor measures the humidity or

   moisture level of dustbin. Due to presence of wet waste, dustbin produces the stinky smell which increases the pollution in surrounding of dustbin and in neighborhood.
3. The real time level of dustbin will send to the given mobile number in fixed and it can have information of bin with time and date.
4. If municipal know about the level of the bin, they can send truck driver to clean the bin. In this way garbage bins can be stay clean and hygienic timely.

A. TO CONTROL THE FUNCTION OF SENSORS

The Arduino Uno is a widely utilized open-source microcontroller board featuring the ATmega328P microcontroller. Recognized for its versatility, it serves as a popular choice for prototyping and do-it-yourself (DIY) electronics endeavours.

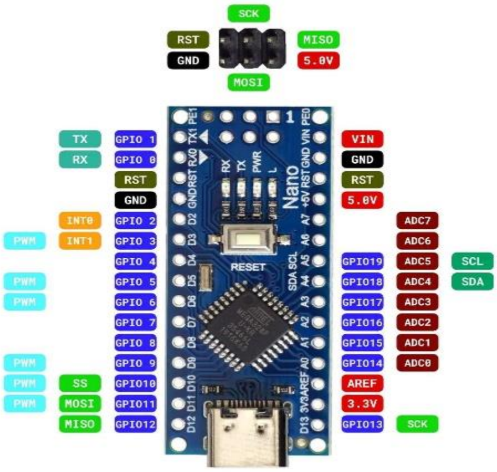

Fig – 4.3 : Arduino-Nano

B. TO MEASURE DUSTBIN LEVELS

For measurement of level, ultrasonic sensor which calculates the spatial between device and waste. We use Ultrasonic sensors operates on the principle of echolocation, similar to how bats and dolphins navigate. These sensors generate and emit ultrasonic waves (sound waves with frequencies above the human audible range) and use the reflection of these waves to ascertain the distance to an object.

Fig – 4.4 : Ultra-Sonic Sensor

This contains a transducer, which is a device that convert electrical energy into ultrasonic waves. It emits a burst of ultrasonic waves in a specific direction. When the ultrasonic waves encounter an object in their path, they are partially reflected back towards the sensor. The object can be solid, liquid, or any surface that reflects sound. The same transducer that emitted the ultrasonic waves now acts as a receiver. It detects the reflected waves returning from the object. The ultrasonic sensor measures the time it takes for the emitted waves to travel to the object and back and calculate the distance. The calculated distance data is then typically converted into an electrical signal, such as a voltage or a digital signal, which can be used by a microcontroller or another device for further processing or control.

C. TO MEASURE DUSTBIN MOISTURE LEVELS

Several non-intrusive moisture sensor technologies can be employed to accurately measure the moisture content in waste. Capacitance sensors, resistance sensors, and optical sensors offer cost-effective and reliable solutions for monitoring moisture levels in various waste types. These sensors are designed to be integrated seamlessly into waste bins or collection points, ensuring minimal disruption to existing waste monitoring infrastructure.

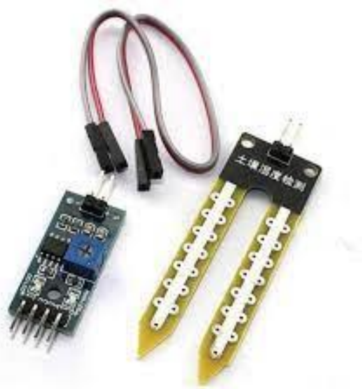

Fig – 4.5: Moisture-Sensor

The moisture sensors with IoT devices allows for real-time data transmission and remote monitoring. This connectivity enables waste management personnel to access comprehensive moisture data.

D. ALERT MESSAGE TO REGISTERED NUMBER

In our system, we utilize the Global System for Mobile Communication (GSM) technology to establish communication between the system and the mobile network. GSM operates as an open digital technology, transmitting data in binary format. In India, it operates within the frequency range of 900MHz to 1800MHz. Specifically, our system employs GSM to send a notification when a dustbin overflows.

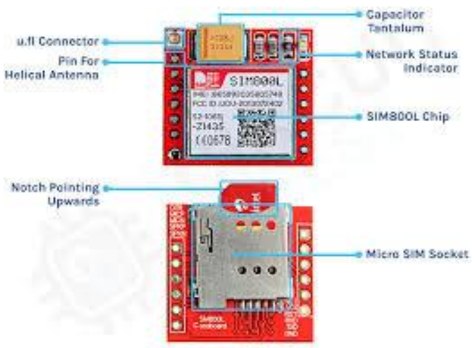

Fig – 4.6: GSM Module Micro Sim Card

CIRCUIT DIAGRAM

SWMS is implemented using GSM module, sensors, and microcontroller. Below circuit diagram shows the integration of hardware to enable monitoring of the bin levels and moisture level and provide real-time data for efficient collection of waste.

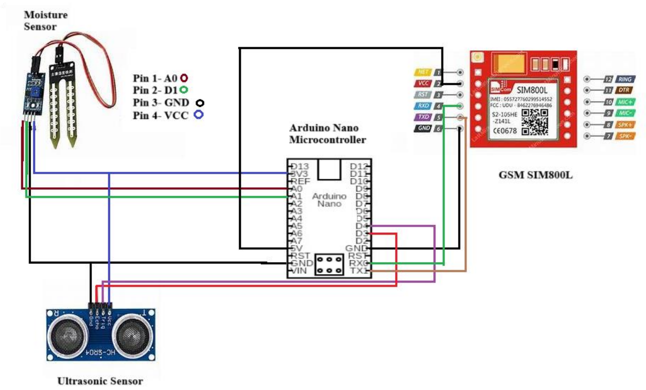

Fig-4.7: Alert Message to Registered Number

Ultrasonic Sensor: Connection of Ultrasonic sensor to Arduino nano are as follows

- Trig Pin: Connected to a digital pin (D4) of the ARDUINO NANO.
- Echo Pin: Connected to a digital pin(D3) of the ARDUINO NANO.
- VCC: Connected to the 3V power supply.
- GND: Connected to the ground (GND).

Moisture Sensor: Connection of moisture sensor to Arduino nano are as follows

- Pin 1: Connected to a digital pin (A0) of the ARDUINO NANO.
- Pin 2: Connected to a digital pin(A1) of the ARDUINO NANO.
- VCC: Connected to the 3V power supply.
- GND: Connected to the ground (GND).

GSM Module: Connection of GSM SIM800L to Arduino nano are as follows

- RX Pin: Connected to the TX pin of the ARDUINO NANO.
- TX Pin: Connected to the RX pin of the ARDUINO NANO.
- VCC: Connected to the 5V power supply.
- GND: Connected to the ground (GND).

Arduino Nano: Connection of Arduino nano are as follows

- GND: Connected to the ground (GND).
- VCC: Connected to the power supply.

5. RESULTS

This project senses the fill level as well as the moisture level of the bin, then sends an alert message about the fill levels of a bin to the registered mobile number. The below image shows the notification of an alert sent to the registered mobile number alerting that Dustbin is full.

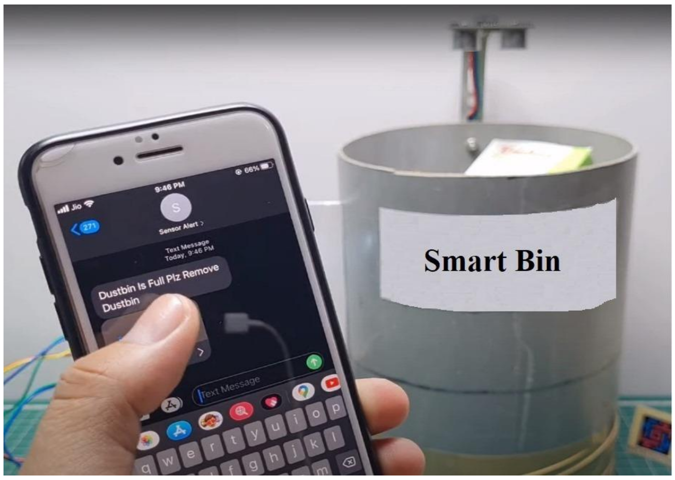

Fig-5.1: Alert Message to Registered Number

6.CONCLUSION

The implementation of a SWMS marks a significant stride towards modernizing waste monitoring practices. This system, using sensor technology has revolutionized traditional waste collection methods by enabling real-time monitoring, optimizing collection routes, and reducing operational inefficiencies. The integration of intelligent bins equipped using sensors not only facilitates timely waste pickup but also minimizes overflowing bins, curbing environmental hazards and promoting a cleaner urban landscape.

REFERENCES

[1]. M. Paturi, S. Puvvada, B. S. Ponnuru, M. Simhadri, B. S.Egala and A. K. Pradhan, "Smart Solid Waste Management System Using Blockchain and IoT for Smart Cities," 2021 IEEE International Symposium on Smart Electronic Systems (iSES), Jaipur, India, 2021, pp. 456-459, doi: 10.1109/iSES52644.2021.00107.

[2]. P. Haribabu, S. R. Kassa, J. Nagaraju, R. Karthik, N. Shirisha and M. Anila, "Implementation of an smart waste management system using IoT," 2017 International Conference on Intelligent Sustainable Systems (ICISS), Palladam, India, 2017, pp. 1155-1156, doi: 10.1109/ISS1.2017.8389367.

[3]. J. Joshi et al., "Cloud computing based smart garbage monitoring system," 2016 3rd International Conference on Electronic Design (ICED), Phuket, Thailand, 2016, pp. 70-75, doi: 10.1109/ICED.2016.7804609.

[4]. R. Tandon and A. Bansal, "IoT-enabled Smart Waste Management: Leveraging the Power of IoT for Sustainable Solutions," 2023 3rd International Conference on Innovative Sustainable Computational Technologies (CISCT), Dehradun, India, 2023, pp. 1-6, doi: 10.1109/CISCT57197.2023.10351210.

[5]. S. Khan, S. Venkat and K. Jayavel, "Autonomous smart waste collection system using internet of things," 2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI), Chennai, India, 2017, pp. 1181-1186, doi: 10.1109/ICPCSI.2017.8391896.

[6]. K. Nirde, P. S. Mulay and U. M. Chaskar, "IoT based solid waste management system for smart city," 2017 International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, India, 2017, pp. 666-669, doi: 10.1109/ICCONS.2017.8250546.

[7]. S. V. Kumar, T. S. Kumaran, A. K. Kumar and M. Mathapati, "Smart garbage monitoring and clearance system using internet of things," 2017 IEEE International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), Chennai, India, 2017, pp. 184-189, doi: 10.1109/ICSTM.2017.8089148.

[8]. A. Imteaj, M. Chowdhury and M. A. Mahamud, "Dissipation of waste using dynamic perception and alarming system: A smart city application," 2015 International Conference on Electrical Engineering and Information Communication Technology (ICEEICT), Savar, Bangladesh, 2015, pp. 1-5, doi: 10.1109/ICEEICT.2015.7307410.

[9]. P. Devi, W. S. Ravindra and S. K. L. V. Sai Prakash, "Implementing an IoT Enabled Smart-Waste Management System for Indian Smart Cities," 2018 2nd International-Conference on Trends in Electronics and Informatics (ICOEI), Tirunelveli, India, 2018, pp. 64-69, doi: 10.1109/ICOEI.2018.8553764.

[10]. S. Ankitha, K. B. Nayana, S. R. Shravya and L. Jain, "Smart city initiative: Traffic and waste management," The conference cited is the “2017 2nd IEEE International Conference on Recent Trends in Electronics, Information and Communication technology (RTEICT)”. Bangalore, India, 2017, pp. 1227-1231, doi: 10.1109/RTEICT.2017.8256794.