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Full Length Article

Smart Waste Management System With Level Indicators For Effective Garbage Segregation

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Abstract
The rapid growth in urbanization and population has increased the generation of municipal solid garbage, providing significant challenges to waste management systems. Hence, to solve the issues in waste management, it suggested Internet of Things (IoT) smart-based Smart Waste Management (SWM) with level indications. This system combines IoT technologies to improve the efficiency and sustainability of the garbage disposal process. The suggested SWM system includes sensor-equipped garbage bins that can monitor and transmit accurate information on their fill levels. Sensor-equipped garbage bins optimize waste disposal by providing real-time data, enhancing efficiency and providing timely predictions in trash management. Furthermore, the use of smart garbage bins helps the separation of various types of waste, increasing eco-friendly behaviours and helping recycling activities. The level indicators not only improv efficiency but also help to reduce environmental effects by lowering overflowing bins and eliminating waste. As a result, this research makes use of the architecture, functionality, and potential benefits of the IoT basedSWM system, highlighting its role in supporting responsible waste management practices, resource conservation, and the development of urban areas.

Keywords; *IoT, IRSensor, Node MCU, HC-SR04 sensor, Thing Speak*

Introduction

The abundant increase in population led to the improper waste disposal. Managing the garbage consumes more time and requires a lot of man power. In recent years the waste disposal is becoming a huge cause. The most of common method of waste disposal is unplanned and it is dumped at the landfill sites this method causes ill effects to all living beings. This method can generate liquid leachate and other fungus which pollute the surface and underground water also accelerates harmful diseases which leads to the degradation of an aesthetic value of environment. In India recycling of solid waste is done by the ragpickers who play an important role in this process while doing the ragpickers get affected with many health problems such as skin infections, respiratory problems the dependent of ragpickers can be reduced if the automatic waste segregation takes place in the dustbin. The wastes are segregated into basic main streams such as metallic, dry and wet this waste has a large potential of recycled and reused. even through there are multiple industrial waste segregators present, it is always better to segregate the waste at source itself. The advantage of doing this type of segregation is, there is no need of rag pickers to segregate the waste. In addition to it the segregated waste can be directly sent to the recycling plant, instead of sending the waste to segregation plant and then to recycling plant. Currently there is no such system for the automatic segregation of waste into dry, wet and metallic waste, the main purpose of this project is compact, low cost and user friendly waste segregation system for urban cities to streamline the waste management process.

Literature Review

K. Harika et al. (2025) developed an intelligent IoT-based waste segregation and monitoring system for smart cities. Their system used sensors and automation to identify different types of waste and monitor bin levels in real time. The proposed model improved waste handling efficiency and reduced manual effort.

M. Al Mamun et al. (2024) proposed an AI-based smart waste classification and monitoring system integrated with IoT technology. Their system used machine learning algorithms for accurate waste classification and real-time monitoring. The study demonstrated improved segregation accuracy and effective waste management.

A. Kumar et al. (2023) designed an IoT-enabled smart waste management system for smart cities. Their approach involved sensors to detect garbage levels and wireless communication for transmitting data to monitoring stations. The system minimized unnecessary waste collection trips and improved resource utilization.

R. Prakash et al. (2022) developed an IoT-based smart waste monitoring and alert system. The system generated automatic alerts when bins were full,

helping authorities respond quickly. Their work highlighted the importance of automation in urban waste management.

Sumit Badotra et al. (2021) developed a smart waste segregation system using IoT. Their work focused on automatic segregation of dry and wet waste using sensor-based detection. The system increased waste processing efficiency and reduced human intervention.

Teoh Ji Sheng et al. (2020) proposed an IoT-based smart waste management system using LoRa communication and a TensorFlow deep learning model. Their system provided long-range communication and intelligent waste classification. The study demonstrated high scalability and suitability for large smart city applications.

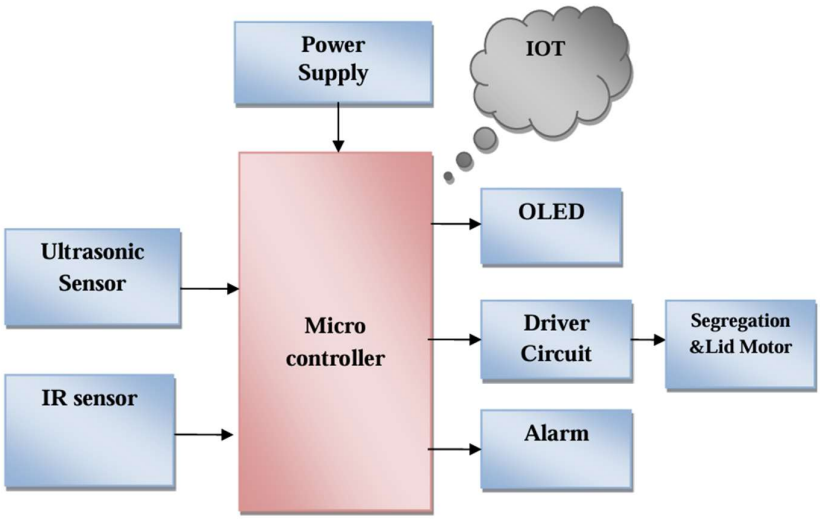
Existing System

The existing waste management systems typically involve regular collection schedules and manual monitoring of waste levels, which often leads to overflows, inefficient collections, and inadequate segregation of different types of waste.

Proposed System

The proposed IoT-based smart waste management system will use level indicators to monitor garbage levels in real-time and facilitate effective segregation of waste types, optimizing collection schedules and improving overall efficiency in waste management.

Block Diagram



Working Principle :

The working principle of the proposed system is based on automatic waste detection, monitoring, and segregation using a microcontroller-based control unit. The power supply provides the required electrical energy to all components in the system. The ultrasonic sensor continuously measures the distance level of the waste material inside the container, helping the system determine whether the bin is full or empty. At the same time, the IR sensor detects the presence of an object or waste near the inlet section. The signals received from these sensors are processed by the microcontroller, which acts as the central controlling unit of the entire system.

After processing the sensor data, the microcontroller sends commands to different output devices. The OLED display shows the current status of the bin and system operation, while the alarm gives an alert whenever the bin reaches a predefined limit or abnormal conditions occur. The driver circuit amplifies the control signals from the microcontroller and operates the segregation and lid motor mechanism for automatic opening, closing, and waste segregation. In addition, the IoT module enables real-time monitoring and data transmission to remote devices or cloud platforms, allowing users to monitor the waste management system efficiently from anywhere.

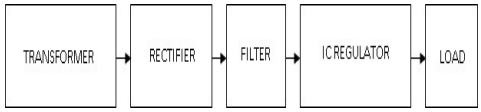
Hardware Implementation :

- ✧ Raspberry Pi Pico W (main controller with Wi-Fi)
- ✧ MQ135 air quality sensor (detects harmful gases)
- ✧ MQ7 sensor (carbon monoxide detection)
- ✧ MQ2 sensor (smoke and combustible gases)
- ✧ DHT11 sensor (temperature and humidity measurement)
- ✧ OLED display (real-time data visualization)
- ✧ Relay module (controls purifier system)
- ✧ Buzzer (alert system)
- ✧ CPU cooling fan (air circulation)
- ✧ UV LEDs (kills bacteria and viruses)
- ✧ 12V power adapter (power supply)

✧ Breadboard/PCB and connecting wires

Power Supply

The power supply section is the section which provide +5V for the components to work. IC LM7805 is used for providing a constant power of +5V.The ac voltage, typically 220V, is connected to a transformer, which steps down that ac voltage down to the level of the desired dc output. This resulting dc voltage usually has some ripple or ac voltage variation.



Bridge Rectifier

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners.

Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B the positive potential at point A will forward bias D3 and reverse bias D4.

MICROCONTROLLER

NodeMCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Expressive Systems, and hardware which is based on the ESP-12 module.

General Purpose Input/Output Interface (GPIO)

ESP8266EX has 17 GPIO pins which can be assigned to various functions by programming the appropriate registers. Each GPIO can be configured with internal pull-up or pull-down, or set to high impedance, and when configured as an input, the data are stored in software registers; the input can also be set to edge-trigger or level trigger CPU interrupts. In short, the IO pads are bi-directional, non-inverting and tristate, which includes input and output buffer with tristate control inputs. These pins can be multiplexed with other functions such as I2C, I2S, UART, PWM, IR Remote Control, etc.

OLED Display

An OLED display have the following advantages over an LCD display:

>Improved image quality - better contrast, higher brightness, fuller viewing angle, a wider colour range and much faster refresh rates.

>Lower power consumption.

>Simpler design that enables ultra-thin, flexible foldable and transparent displays.

Better durability - OLEDs are very durable and can operate in a broader temperature range.

ULTTRASPNIC SENSOR

Ultrasonic sensors are industrial control devices that use sound waves above 20,000 Hz, beyond the range of human hearing, to measure and calculate distance from the sensor to a specified target object.

IR SENSOR

An Infrared (IR) Sensor is an electronic sensing device used to detect and measure infrared radiation emitted or reflected by surrounding objects. It works by transmitting infrared light through an IR LED and receiving the reflected radiation through a photodiode or phototransistor. When an object comes near the sensor, the infrared rays strike the object and reflect back to the receiver, which converts the reflected light into an electrical signal. This signal is then processed by the internal circuit to indicate the presence or absence of an object. IR sensors are widely used in embedded systems, robotics, automation, security systems, obstacle detection, line following robots, automatic doors, and remote-control applications because they provide fast response, accurate detection, low power consumption, compact size, and reliable performance without physical contact with the object.

RELAY

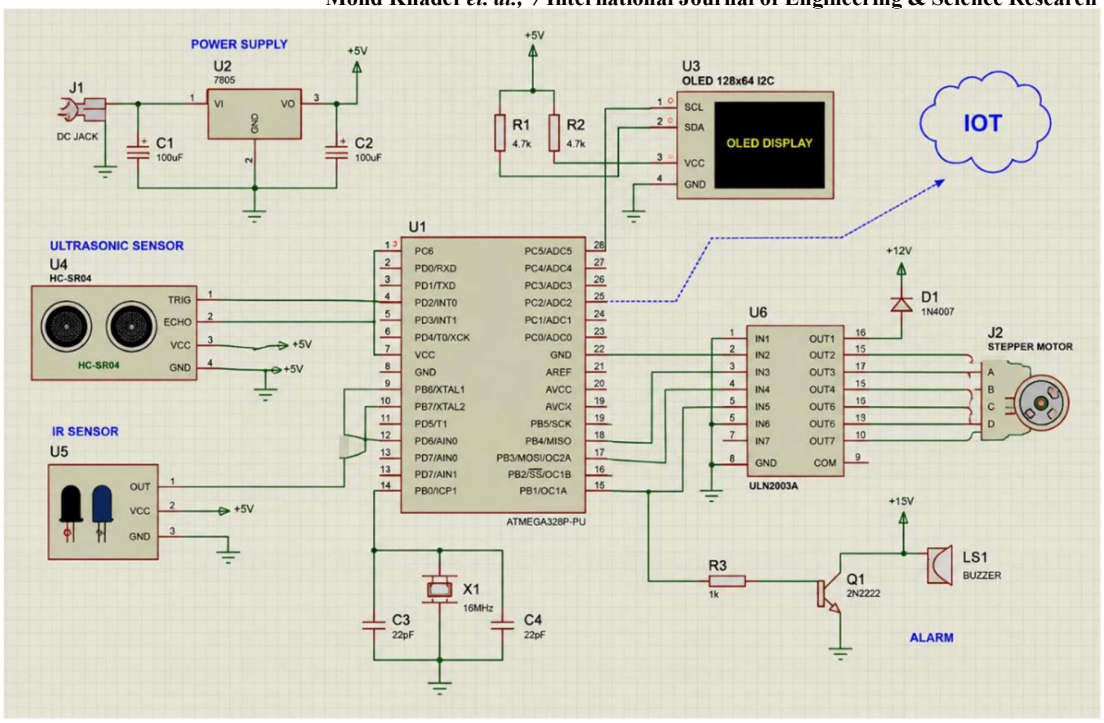
A relay is an electromechanical switch, which perform ON and OFF operations without any human interaction. General representation of double contact relay is shown in fig. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal.

BUZZER

A buzzer or beeper is a signalling device, usually electronic, typically used in automobiles, house hold appliances such as a microwave oven, or game shows.

It most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. Initially this device was based on an electromechanical system which was identical to an electric bell without the metal gong (which makes the ringing noise).

SCHEMATIC DIAGRAM



RESULTS

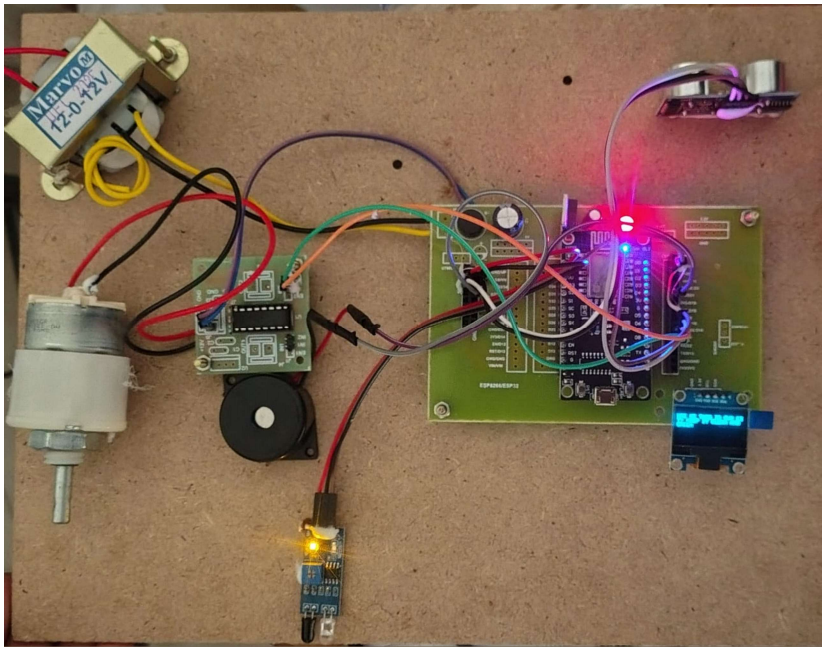


Fig.2: Hardware Kit in ON Condition

All sensors and components are active. The system begins collecting and processing environmental data. Here NODE MCU ESP8266 initializes all connected sensors and begins real-time data acquisition. The sensors start detecting environmental parameters. Output devices such as the OLED display and IoT module become active

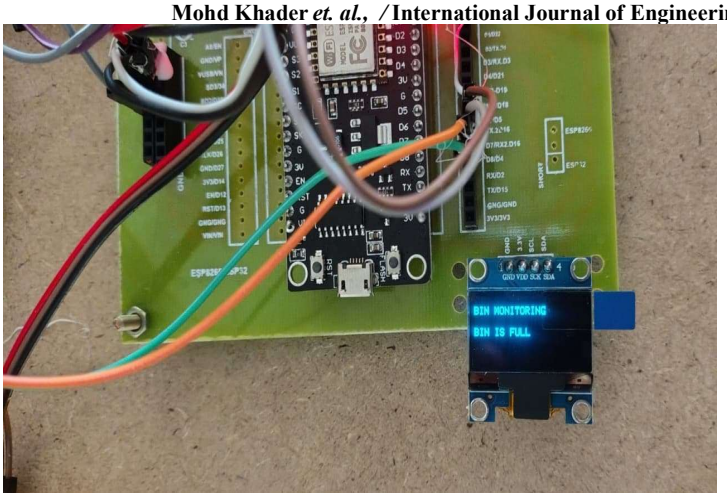


Fig.3: Display shows Temperature and Humidity values

The OLED display in this figure shows real-time dust bin condition. The values are updated periodically and displayed in a clear, readable format. This helps users understand the surrounding environmental conditions instantly.

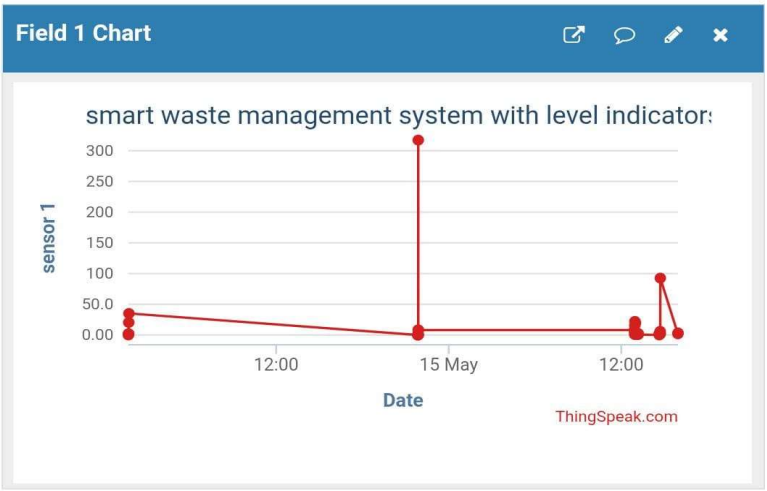


Fig.6 : Displaying sensors data through Things peak

This figure illustrates the graphical representation of sensor data uploaded to the ThingSpeak cloud platform. The data is transmitted via Wi-Fi using the Node MCU ESP8266 and stored for analysis. The graph shows variations in pin parameters This feature enhances the system's usability by providing real-time access from anywhere.

CONCLUSION:

With growing urbanisation and increasing population, effective waste disposal has become a major challenge for modern cities and communities. Traditional methods of waste collection and segregation are often inefficient, labour-intensive, time consuming, and costly. Improper disposal of waste also leads to environmental pollution, health hazards, and poor management of municipal resources. To overcome these limitations, this project presents a Smart Waste Management System with Level Indicators using IoT technology.

The proposed system provides an intelligent and automated approach for monitoring and managing waste collection. By using sensors to detect the garbage level inside the bins, the system continuously monitors the fill status and sends real-time information to the concerned authorities through IoT connectivity. This helps in ensuring timely waste collection before the bins overflow. In addition, the smart segregation mechanism efficiently separates wet and dry waste with minimal human intervention, improving recycling efficiency and reducing manual effort.

FUTURE SCOPE

1. Integration of AI for automatic waste segregation.
2. Real-time monitoring through IoT and mobile applications.
3. GPS-based smart waste collection system.
4. Addition of gas and temperature sensors for safety.
5. Solar-powered operation for energy efficiency.

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