TRASH TRACKER; A WASTE MANAGEMENT SYSTEM

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ABSTRACT

The smart waste management system "Trash Tracker" is an application to advance waste disposal. As concerns about environmental issues become increasingly apparent and urban waste management systems are challenged, the need for better waste management is crucial for sustainability. Trash Tracker utilizes advanced sensors, microcontrollers, and real-time data analytics to facilitate monitoring waste levels, optimize disposal routes, and improve recycling efforts. Now with added smart cellular communication, automated alerts and analytics make for data-driven decisions. The implementation of this technology leads to waste management solution can lead to increased urban cleanliness, reduced land waste, and improved resource management. In addition, the research paper explores city, industry, and domestic applications for the Trash Tracker and its capacity to advance sustainability. By separating real-time monitoring from predicting analytics the Trash Tracker can be applied as a new solution to global waste management challenges. This paper aligns with the sustainable development goals, developing increased environmental awareness along with community action in responsible waste disposal.

Keyword *: Smart Waste Management, Real-Time Monitoring, Sustainability, Data-Driven Decisions, Recycling Optimization*

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1. INTRODUCTION

The waste management aspect of modern urban development has a direct bearing on the environment and health. Due to the increasing rate of waste generation, traditional disposal methods have frequently been incapable of coping with effective waste management requirements, thereby giving rise to an acute necessity for the development of novel collection, segregation and recycling processes.

The Trash Tracker is meant to tackle these very concerns by incorporating accidental smart technologies in waste management systems. This is done by providing IoT GPS tracking, sensor networks, and automation for real-time monitoring and effective waste disposal solutions. The strategy involves source segregation of waste material into dry waste, wet waste, e-waste, and metals/non-metals. Additionally, the proposed ultrasonic sensors will gauge the bin filling level and generate alerts accordingly at different stages of waste collection. Another intention behind the introduction of such technological solutions is to minimize the large scale pollution of the environment, improve work efficiency, and promote sustainable waste disposal. Besides, the Trash Tracker initiative is also in line with government programs such as Swachh Bharat Abhiyan and smart city projects that are geared toward the cleaning and greening of urban spaces. The introduction of the Trash Tracker can modernize waste management by reducing human interferences while improving accuracy, affordability, and sustainability.

2. OVERVIEW OF THE SYSTEM

The Trash Tracker is an innovative waste management system designed to optimize waste collection and disposal processes using smart technology. The system integrates IoT-based sensors, GPS tracking, and wireless communication to monitor waste levels in bins and provide real-time data to authorities. The system works by installing ultrasonic and gas sensors in trash bins to detect the waste level and type (dry, wet, e-waste, or metal). When the bin reaches 50% capacity, an alert is sent to ward members, and when it reaches 90% capacity, an alert is sent to the government authorities for immediate action. The system tracks the waste journey using GPS technology, ensuring efficient collection and disposal while reducing overflow and pollution.

Additionally, the Trash Tracker utilizes cloud-based data analysis to optimize garbage collection routes, minimizing fuel consumption and operational costs. The project supports smart city initiatives and aligns with government programs like Swachh Bharat Abhiyan. It promotes sustainability by encouraging proper waste segregation and recycling efforts. By implementing automated waste tracking and optimized collection scheduling, Trash Tracker reduces manual intervention, improves waste management efficiency, and contributes to a cleaner and healthier environment.

3. COMPONENTS

The Trash Tracker system consists of several key components that enable efficient waste monitoring and management.

3.1 Arduino Uno: The microcontroller used to process sensor data and control the system. It facilitates communication between sensors and other hardware components.

3.2 NodeMCU ESP8266: A Wi-Fi-enabled microcontroller that allows real-time data transmission to a central database or cloud platform for remote monitoring.

3.3 Ultrasonic Sensors: These sensors measure the waste level in the bin by emitting sound waves and detecting the time taken for the echo to return. This helps determine when the bin is nearing full capacity.

3.4 MQ-7 Gas Sensor: Detects harmful gases such as methane and ammonia, ensuring early detection of hazardous waste and improving environmental safety.

3.5 GPS Module: Tracks the location of bins and waste collection vehicles, allowing authorities to optimize routes and improve efficiency.

3.6 Buzzer: Provides an alert when the bin reaches a predefined waste level, ensuring timely collection.

3.7 LCD Display: Displays real-time bin status, including waste level and gas detection, for easy monitoring by users.

3.8 Power Supply: Ensures continuous operation of the system, typically using a battery or direct power source.

4. BLOCK DIAGRAM

The Trash Tracker system is a smart waste management solution that integrates sensors, microcontrollers, wireless communication, and cloud-based monitoring to improve efficiency in waste collection and disposal. The block diagram represents the interaction between the system's various components and their functions in ensuring an automated waste tracking process.

At the core of the system lies the Arduino Uno microcontroller, which acts as the central processing unit. It receives input data from different sensors and processes it to determine the bin's status. The ultrasonic sensor plays a crucial role in monitoring waste levels in the bin. It works by emitting sound waves and measuring the time taken for the waves to bounce back, allowing it to detect whether the bin is empty, half-full, or full. This data is sent to the Arduino Uno, which then determines whether an alert should be triggered.

Another essential sensor in the system is the MQ-7 gas sensor, which detects harmful gases such as methane, ammonia, and carbon monoxide that may be emitted from decomposing waste. If the gas levels exceed a predefined threshold, the system automatically sends an alert to the concerned authorities, ensuring timely intervention to prevent hazardous situations. This is particularly useful in landfills or waste bins located in residential areas, hospitals, or industrial zones, where toxic gases can pose significant health risks.

The GPS module is another critical component of the Trash Tracker. It provides real-time tracking of garbage bins or waste collection vehicles. This information is useful in route optimization, helping garbage collection teams navigate efficiently, reduce fuel consumption, and minimize operational costs. The GPS data is transmitted to a cloud server, allowing authorities to monitor waste collection remotely.

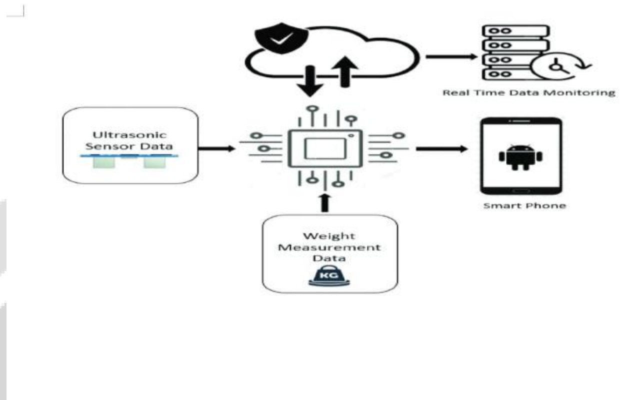

Fig 1: Block Diagram

A buzzer is included as an alert mechanism. It activates when the waste bin is nearly full or when the gas concentration exceeds safe levels. The buzzer serves as an immediate notification for nearby personnel, prompting quick action to prevent overflow and environmental hazards.

The entire system operates on a battery-powered or solar-powered setup, ensuring uninterrupted functionality. In smart city initiatives, solar panels can be used to make the system energy-efficient and environmentally friendly. This power supply mechanism ensures that the Trash Tracker operates continuously, even in remote areas where electrical connections may not be readily available.

Overall, the Trash Tracker system effectively automates the waste collection process by leveraging IoT-based smart monitoring. The combination of sensors, microcontrollers, GPS tracking, and cloud connectivity ensures that waste is collected efficiently before it overflows, reducing pollution and promoting a cleaner environment. The system’s ability to send real-time notifications and optimize waste collection routes makes it a valuable asset for smart cities, municipalities, and corporate waste management programs. By implementing this system, cities can significantly improve their waste management strategies, reduce operational costs, and support sustainability efforts like the Swachh Bharat Abhiyan

5.WORKING PRINCIPLE

The Trash Tracker system operates on a smart and automated waste management principle, integrating IoT-based sensors, GPS tracking, and wireless communication to optimize garbage collection and disposal. The system's working process involves data collection, processing, alert generation, and remote monitoring to ensure waste is managed efficiently. The operation begins with sensor-based waste level detection. Ultrasonic sensors installed inside the bin measure the level of accumulated waste by emitting sound waves and analyzing their reflection time. When the bin reaches 50% capacity, an alert is sent to ward members, and when it reaches 90% capacity, a notification is sent to government authorities for immediate action. This real-time monitoring helps in preventing bin overflow and maintaining hygiene

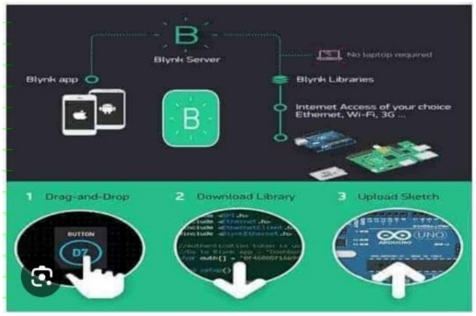

Fig 3: Working Principle

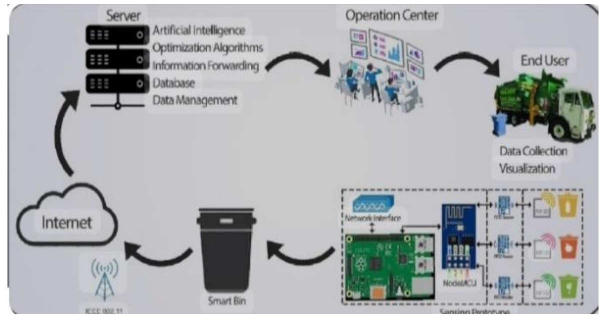

Fig 4: Waste Management

All collected data is processed by the Arduino Uno microcontroller, which communicates with the NodeMCU ESP8266 Wi-Fi module to send real-time updates to a cloud-based monitoring system. Authorities can access this data via mobile applications or web dashboards, making remote monitoring easy Finally, the system includes a buzzer for on-site alerts and an LCD display to show the bin’s waste level, gas concentration, and GPS location. This ensures that waste collection is timely, efficient, and environmentally sustainable, supporting smart city initiatives and pollution control efforts.

6. IMPLEMENTATION OF CODE

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(8, 9, 10, 11, 12, 13);

int tr=A0;
int ec=A1;
int buz=7;
int  depth;

 int gs=A2;
 int cnt1=0;
 #include <TinyGPS.h>
TinyGPS gps;
float flat=0, flon=0;
#include <SoftwareSerial.h>
#include <Wire.h>
SoftwareSerial gpsSerial(2, 3); // RX, TX
void read_gps()
{
  bool newData = false;
  unsigned long chars;
  unsigned short sentences, failed;
  for (unsigned long start = millis(); millis() - start < 1000;)
  {
    while (gpsSerial.available())
    {
      char c = gpsSerial.read();
      if (gps.encode(c))
        newData = true;
    }
  }
```

```
 if (newData)
 {

   unsigned long age;
   gps.f_get_position(&flat, &flon, &age);

 }
}

void setup()
{
  lcd.begin(16, 2);
  lcd.print("    WELCOME");
  Serial.begin(9600);
  pinMode(buz,OUTPUT);
  pinMode(ec, INPUT);
  pinMode(tr,OUTPUT);
  pinMode(buz,OUTPUT);
  digitalWrite(buz,0);


  lcd.clear();
  lcd.print("SMART BIN");
  delay(500);
  gpsSerial.begin(9600);
  Serial.begin(9600);
 read_gps();
```

```
}
void loop ()
{

     digitalWrite(tr,0);
     delayMicroseconds(2);
     digitalWrite(tr,1);
     delayMicroseconds(10);
     digitalWrite(tr,0);
     delayMicroseconds(2);
     depth=25-pulseIn(ec,1)/58;
    if(depth<0)
      depth=25;
       read_gps();

    int gval=analogRead(gs)/10.23;
     lcd.clear();
     lcd.print("LVL:"+String(depth) +" G:"+String(gval));
     lcd.setCursor(0,1);
     lcd.println("LT:"+String(flat,1)+" LG:"+String(flon,1));

   if(depth>20|| gval>30)
  {
  digitalWrite(buz,1);
  delay(100);
  digitalWrite(buz,0);
   read_gps();
}
delay(1000);
      cnt1=cnt1+1;
```

```
    if(cnt1>15)
    {
     cnt1=0;
    Serial.print("669301,SXRHXBDFMUO6102V,0,0,SRC 24G,src@internet,"+String(depth)+","+String(gval)+",0\n
");
    }
 }
```

Fig4: Implementation of Code

7. Advantages and Future Scope

1) **Real-Time Monitoring:** Tracks garbage levels in bins, ensuring timely collection and reducing overflow.
2) **Optimized Waste Collection:** Uses smart routing to minimize operational costs and fuel consumption.
3) **Cost-Effective:** Reduces expenses associated with inefficient waste management practices.
4) **Environmental Benefits:** Prevents pollution, reduces landfill overflow, and promotes sustainability.
5) **Data-Driven Insights:** Analyzes waste patterns to improve decision-making for municipalities and businesses.
6) **Integration with IoT & AI:** Enhances automation for efficient waste collection and processing.
7) **Public Awareness & Engagement:** Encourages responsible waste disposal and recycling habits.
8) **Health & Hygiene Improvement:** Reduces risks of disease outbreaks by preventing waste accumulation.
9) **AI-Powered Predictive Analytics:** Forecasts waste generation trends for proactive collection planning.
10) **Automated Waste Segregation:** Enhances recycling by sorting biodegradable and non-biodegradable waste automatically.
11) **Blockchain Integration:** Ensures transparency in waste tracking and disposal management.
12) **Smart City Integration:** Connects with urban infrastructure for efficient waste management.
13) **Waste-to-Energy Solutions:** Converts waste into usable energy, promoting sustainability.
14) **Gamification & Public Incentives:** Encourages citizen participation through reward-based programs.
15) **Drone-Based Monitoring:** Enhances landfill and illegal dumping surveillance.
16) **Global Scalability:** Can be adopted worldwide, helping developing nations achieve efficient waste control.

8. Conclusion

Trash Tracker presents an innovative solution for efficient waste management through real-time monitoring, optimized collection routes, and cost reduction. By leveraging IoT and AI, it enhances automation, reduces pollution, and improves public hygiene. Looking ahead, integrating AI-powered analytics, blockchain transparency, and waste-to-energy solutions can revolutionize waste disposal. With smart city integration and global scalability, Trash Tracker holds immense potential for transforming urban waste management, ensuring sustainability, and fostering cleaner, healthier communities.

9. Acknowledgement

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