**A SMART WASTE MANAGEMENT SYSTEM FOR MONITORING, COLLECTION, AND PROPER DISPOSAL.**

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**Abstract**

The ability of smart cities to deal with environmental issues in general, and trash management in particular, is an important topic that requires scientific investigation. Any unpleasant, harmful, or wasteful substance produced by daily human activities and municipal events is considered solid waste. Solid waste management is the approach for managing solid waste creation, storage, collection, transport, treatment, and disposal. Solid waste management is characterized based on the availability of economic capital and the degree of industrialization progress.

A smart solid waste monitoring and collecting system is proposed and explained in this article. The system is made up of smart containers or smart bins, each with an Arduino Uno, ultrasonic sensor, and Radio Frequency (RF) transmitter mounted on top. When a container is full of waste, it sends a signal to the control center, which has the amount of waste in containers, and a message (SMS) is sent to the truck driver's mobile phone, indicating which trash bin is full and need to be empty. Finally, an efficient system and waste disposal approach are provided that may be employed in the future to improve performance and cost-effectiveness.

**Keywords:**  SolidWaste Management, Sustainable and Smart Cities, Environment, smart bins.

**Introduction**

The rapid growth of industrialisation and human population has resulted in increased amounts of rubbish generation in metropolitan areas. To conserve the environment, the number of garbage cans should be raised and strategically positioned for real-time monitoring and pickup. Without adequate trash collection and disposal, rubbish containers would be overfilled and spill out into the surrounding area, causing health hazards for humans and the environment (Akhil 2017). In city life one of the most important components is Municipal Solid Waste (MSW) . Annual solid waste creation is expected to exceed 1.3 billion tons, with a projected increase to 4.3 billion tons by 2025, when 50% of the world population would be present (Hoornweg and Bada, 2012). Due to the massive amount of solid waste created by residential and commercial-industrial regions, coordinating garbage collection is one of the most difficult jobs in the rural environment. Furthermore, garbage collection accounts for 50-70% of total solid waste management costs. Because of the enormous amount spent on collecting, there is only a little amount accessible for collection enhancement (Tchobanglas and Kreith ,2002). The waste management cycle begins with the production of rubbish from companies, homes, markets, and other sources, which is subsequently disposed of in garbage cans. Municipalities gather this trash and dispose of it in dumping zones and landfills. Some waste is not collected because to a lack of resources and an ineffective foundation, causing a significant health danger to the local environment. Cleaning at regular intervals may be able to solve this problem. Manually tracking the status of the bin, on the other hand, is a difficult operation (Singh et al,.2016). A smart garbage monitoring and collecting system is being created in order to save money and time on waste collection while simultaneously protecting the public environment,public health, and providing a safe living environment. Waste collection and monitoring employing cutting-edge technology such as Radio Frequency (RF), ultrasonic sensors, GSM/GPRS, and Arduino provide a fresh viewpoint on waste management system optimization.

**Current status of India**

According to the CPCB Report 2013, no city in India achieves 100% trash segregation, and only 70% of total garbage is collected and segregated at housing sites. The remaining 30% of uncollected rubbish is left in the environment or gets mixed up. The fundamental issue is that only 12.45 percent of the collected garbage is handled under scientific circumstances, while the rest is dumped in open places shown in figure 1.

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**Figure:-1 Current waste management statistics of indian cities (Joshi et al., 2016).**

**India's waste generation**

While maintaining its physical, climatic, geographic, ecological, social, cultural, and linguistic diversity, India is becoming more urbanized (Bhalla 2013). India's population increased from 1028 million in 2001 to 1252 million in 2013. According to the 2011 Census of India, population increase in India is mostly to blame for rising MSW. The scale of India's megacities is expanding. A recent development linked to economic, cultural, and technological globalization is the emergence of megacities (ISWA) (International Solid Waste Association 2012). Ahmedabad (6.3 million people), Hyderabad (7.7 million), Bangalore (8.4 million), Chennai (8.6 million), Kolkata (14.1 million), Delhi (16.3 million), and Greater Mumbai are some of the megacities in India (18.4 million).

From generation to final disposal, municipal solid waste management operations may be divided into six functional areas (Ashish et al.,2014).

• Waste production

• Waste storage

• Gathering

• Transportation

• Sorting & Processing

• Disposal

**Waste segregation**

IoT for waste segregation was introduced by Lopes and Machado in 2019. In addition, the framework analyzes the appearance of garbage and classifies it as dry, wet, and metallic waste at the family unit level. It also helps with ongoing monitoring of trash levels in dustbins. Additionally, it makes use of GSM and Arduino to show the amount of trash in the trash cans on an LCD screen and send a message to clean up when it is full. A simple garbage monitoring system was developed to aid the Swachh Bharat Abhiyan by Bharadwaj B et al. The main idea behind the work is to separate garbage of the same kind and put it in a transit line with wet waste gathered containers on one side and dry waste gathered containers on the other. The data will be made available to the general public. We can rapidly verify the data and track the car using this tool. Glouche and Couderc (2013) developed smart trash management through the use of self-describing goods. The framework's main goal is to continually reduce and reuse garbage. RFID technology is utilized to track each item's arrival. It also employs low-cost QR code technology. The data acquired is used to categorize garbage into three categories: glass, plastic, and paper/cardboard. The information about the garbage in each container is critical throughout the recycling process. Singh et al. (2014) talk about the significant growth in Municipal Solid Waste. Handpicking is a technique for sorting municipal solid refuse. Its only capability is to separate bulk materials. Trammel screens are used to separate inorganic minerals, whereas magnetic and electromechanical devices are used to separate ferrous and nonferrous metals. In order to recover energy, segregated garbage is reduced via incineration. Solid waste can be categorized and segregated into components suitable for the thermal conversion process.

**Waste collection**

The researchers want to identify problems with the waste collection process and provide methods to increase efficiency. The model is divided into three sections: a data collecting layer, a waste disposal approach, and trash disposal zones. The ultimate product is a comprehensive framework with Inputs, Outputs, Guides, and Enables. The data is stored on a cloud server managed by the local government (Lokuliyana et al.,2017). RFID, GPRS, GPS, and a camera are all part of the planned trash identification system. The device recognizes the RFID waste tag and sends data about the rubbish in the bin. The data transmitted is recorded in a central monitoring station and used to control the trash disposal process. The bin pictures are collected using MATLAB image processing tools and the MySQL data server (Islam et al.,2012). Using Sensor structures, the developer designed an IOT-based clean organization system that monitors rubbish levels above dustbins. As soon as the GSM/GPRS worry was detected, this system replied. The outcome is then shown in an Android application, where the user may acquire information on the bin's location. The model examines elements linked to fuel utilization, toxin discharges, truck speed, and carried limit as part of the improvement interaction.

**Waste collection using solar methods**

Kabir et al.,2020 presented a smart waste system based on IOT and regulated by sunlight. There are five receptacles nearby that are wired to the Arduino Mega. The sun-oriented force provides each waste with controlled DC capability. When the canisters reach an abnormally high amount of waste, a warning is sent by both electronic and SMS alerts.

**Waste collection using machine learning**

Estrada Elsa.,2018 used machine learning to construct a smart city visualization tool. The author concentrated on three frameworks: smart tracking, which detects typical urban occurrences, smart citizen tools, which monitor people's everyday interactions, and smart visualization, which monitors the environment, energy, and transportation. Catania and Ventura (2014) created the Smart-M3 platform, which allows data to be exchanged between devices while remaining flexible. The clever framework depicted focuses on two structures: the first is aimed at governments and privately owned businesses in order to design an ideal asset management and waste collection arrangement; the second is aimed at residents in order to allow them to know the condition and location of the nearest canisters and encourage them to reuse.

**Waste management using cloud**

The method for controlling household waste was proposed by (Yusaf et al.,2017). The ultrasonic sensor measures the amount of garbage in each canister and communicates the data to the Arduino Uno. Furthermore, various colored LEDs are included inside the bin's sensor platform to indicate the threshold level. The framework developed is particularly useful in increasing local communities' proficiency in good waste management. The author creates a revolutionary garbage sorting system using deep learning to encourage reuse and elimination. In the Darknet neural organizing system, the YOLOv3 computation was employed to produce a distinct set of data. YOLOv3 has difficulty distinguishing between things made of more than two materials according to Kumar and his colleagues (2002) shown in figure 2.



**Figure: -2 Cloud-based smart waste management architecture (Aazam et al., 2016**)

Sensors in each bin in the planned Cloud SWAM detect the amount of garbage in the container. The smart bin is depicted in Figure 3, with (A), (B), and (C) illustrating different bins for each waste category, namely organic, plastic/paper/bottle, and metal. Each sort of rubbish is already segregated in this fashion, and the status displays how much waste is collected and what type of waste it is. This form of pre-separated rubbish is employed in places like Korea, to name a few, and it considerably assists waste management. In (D), an example of a warning message appears when the trash level exceeds a specified level at which garbage collectors must plan collection. While (E) shows that the bin is empty, the user and garbage collectors are kept up to date without having to reach for it or open it to verify the status.

**Figure:-3 Smart bins for different waste categories, equipped with waste status notification.**

**Waste collection using Internet of Things (IoT)**

Municipal governments and legislators are working hard to improve rubbish collection and disposal in cities. The bin is separated into three sub-canisters, each of which collects a distinct sort of rubbish. To recognize garbage in the bin, an infrared sensor is employed. A moisture and metal sensor is used to distinguish between wet and metal waste. Bins are located using GSM technology. The trash information obtained is transferred via the ESP8266 wife module. On the Thinkspeak server, the waste count is updated (Sowndharya and Savitha,2019) Chitluri Sai Srikanth et al. presented a smart waste management system-based rubbish collection solution based on IoT shown in Figure 4.As a result, we can maintain proper separation from the contaminants indicated by the trashcan, and waste stink is reduced (Jasmin et al.,2021). Waste management difficulties, according to the author, are increasingly deteriorating. Temperature and humidity sensors are used to distinguish between wet and dry waste. The junk data is processed using a Raspberry Pi microcontroller. The devices' master-slave design reduces connectivity problems in faraway locations (Elhassan et al.,2016).

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**Figure: -4 Waste collection (source -Sowndharya,2019)**

**Waste monitoring**

Navghane et al. (2016) guarantee that the trashcan will be cleaned as soon as the rubbish level reaches a crucial level. If the garbage can is not empty, an alert is sent to higher-ups, who can then take appropriate action. The strategy lowers total costs while also reducing corruption in the management system. The cloud maintains data about the volume and kind of rubbish. As a result, getting data from the cloud is straightforward. Furthermore, based on the state of the waste container, professionals can choose the collecting technique. It increases time efficiency (Aazam et al.,2016).

 (Zavare et al., 2017) and colleagues presented a smart container with a unique ID as a rubbish management solution. When the compartment is full, the (GSM) warning signal notifies the waste management firm the holder ID and region. The status of the empty bin is also reported to the proper authorities following rubbish collection

**Conclusion**

Local urban solid waste avoidance and recycling are critical, rather than depending primarily on regional treatment and disposal. Although the specialized collection is necessary, it puts current waste collection systems under strain. This study developed a smart and green system (SGS) that combines the in-depth integration of various informatics with the strategy of sustainable waste management to bridge this gap and provide an efficient, effective, and sustainable scheme. Technological advancements in a variety of fields have offered the new potential for improved service delivery. Another area where present technical capabilities may be put to greater use as the population grows and lifestyles change is waste management.A number of environmental authorities and parties are involved in the waste management process. A solid waste management system is essential for improving not just the entire process but also garbage disposal. Resources for waste management may also benefit the food sector, healthcare, tourism, and other businesses. The suggested cloud-based waste management system provides a more effective manner of processing and disposing of garbage, as well as aiding in a variety of future research topics such as food, hygiene, the environment, socio-cultural challenges, lifestyle, and so on.

In the future, this study might be expanded to incorporate case studies or country-specific rubbish-generating trends. Big Data analysis may be used to data from a variety of sources.

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