

## Literature Review: Smart Trash Bin Innovation Based on The Internet of Things

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### Abstract

Waste management is an increasingly pressing global challenge. Smart trash cans based on the Internet of Things (IoT) offer a solution by utilizing technology to enhance the efficiency and effectiveness of waste management. However, there are still several research areas that have not been thoroughly explored, such as the use of AI and Machine Learning technology in predicting waste disposal patterns, managing specific types of waste, and integrating smart trash cans with city-wide waste management systems. Further exploration in these areas can assist in the development of smarter and more effective trash cans, positively impacting the environment and community welfare. Therefore, further research is crucial to continue optimizing this technology and creating more sustainable waste management solutions.

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Smart Trash Can  
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### Introduction

Waste bins, as temporary waste storage containers, play an important role in waste management and the prevention of disease spread and environmental pollution. Along with the development of technology and increased environmental awareness, the concept of trash cans has evolved to become more sophisticated and environmentally friendly, one of which is a smart trash can based on the Internet of Things (IoT).

IoT is a concept in which everyday objects are equipped with unique identification and the ability to transfer data over the internet network without requiring human-to-human or human-to-computer interaction. In the context of garbage bins, IoT can be used to monitor the capacity of the bin in real-time and provide notifications when the bin is full.

IoT-based smart bins work by using sensors placed inside the bin to measure the fill level and send a notification to the municipal waste collection service when the bin is ready to be emptied. Over time, the historical data collected by the sensors can be used to identify filling patterns, optimize driver routes and schedules, and reduce operational costs.

In addition, the machine learning capabilities of the smart bins work with, real-time data collection, which is then transferred to the cloud platform via WiFi. Software in the cloud then processes the data and transmits it to the user interface for final reaction. Smart bins function as IoT devices to spontaneously select and

compress recyclable items. In general, modern bins are equipped with sensors to detect their filling level, and application gateways connect IoT platforms. They also have sensors that send data from the bins to servers in the cloud. The IoT platform processes the raw data into actionable information.

The application of IoT to trash bins has many benefits, including: increasing the efficiency of waste collection, reducing operational costs, preventing waste accumulation, and helping in environmental conservation efforts. With the increasing production of waste in the world, there is a need for more efficient and effective solutions in waste management. IoT-based smart waste bins offer such solutions by utilizing technology to improve the efficiency and effectiveness of waste management.

The purpose of this article is to examine various models of IoT-based smart trash bins, as well as their benefits and potential in waste management. It is hoped that through this article, readers can gain a better understanding of the importance of innovation in waste management.

### Research method

The method used in writing this article is literature review. The search was carried out by using several databases such as Google Scholar and Science Direct.

There are several studies that develop IoT-based smart trash can models. First, research by Juwariyah et al. which discusses the development of IoT-based smart trash cans that can monitor waste capacity and detect smoke using smartphone applications. This trash can uses NodeMCU 8266 as the main control, ultrasonic sensors to detect the distance of garbage capacity and object distance, and servo motors to move the trash lid automatically. The MQ-2 smoke sensor is used as a smoke marker, and the ESP 8266 Wifi module is used to send notifications via the internet. The trash can can be monitored with the Blynk application. The results show that the trash can lid will automatically open when the object is within 10cm to 1cm, and the sensor can detect the full capacity level of the trash when the trash is 5cm to 1cm away from the sensor. In addition, when the smoke capacity exceeds 325ppm, the buzzer will turn on and the system will send a notification message to the janitor's smartphone.

Furthermore, research by Ariessanti et al. focused on the development of an automatic waste disposal system at SMAN 14 Tangerang Regency to improve the efficiency and cleanliness of the school environment. This system uses ultrasonic sensors and Wemos D1 to monitor the volume of the trash can and provide notifications to the janitor when the trash can is full. In addition, this system can also deliver the trash bin to the final bin through a linear actuator. Thus, this system not only helps human work but also provides notifications regarding the capacity of shelters and bins.

Then, research by Darmansyah et al. discusses the development of an IoT-based automatic trash can that uses a hybrid PV- grid system as a power source. This trash can is equipped with ultrasonic sensors and a GSM module connected to an Arduino Uno microcontroller to detect the level of garbage filling and send notifications to janitors when the trash can is full. The system can fully recharge the battery in 3.39 hours and can send a notification if the ultrasonic sensor detects garbage within 20 cm for 5 seconds.

This tool is also equipped with a servo motor to separate metal and non- metal waste, a 20x4 LCD display, and a ThingSpeak application to display waste capacity. The test results showed an error of 3.3% on metal waste and 4.61% on non- metal waste in reading the waste capacity. Research by Utomo et al. aims to design an organic and non-organic waste separation system based on Arduino and NODEMCU. The system uses three main sensors: infrared sensor to detect all waste, proximity sensor to detect organic material, and capacitive proximity sensor to detect non-organic waste. In addition, the system also uses a load cell sensor to determine the weight of the

waste. The system is designed to provide accurate readings, with the success rate of sensor readings reaching 100% if the organic material reading is based on the reading of the capacitive sensor, while the non-organic material reading is a combination of the readings of two sensors, namely inductive and infrared sensors. The system is also equipped with IoT to monitor the condition of the trash can in real-time.

Another research focuses on developing a device to detect methane gas produced by organic waste, which can cause respiratory distress and explosion. This tool uses an MQ-4 sensor to detect the concentration of methane gas and a DHT22 sensor to detect the temperature and humidity of the air in the trash can. The monitoring and data processing process is supported by an ESP32 microcontroller with an internet network, in accordance with IoT principles, and can be monitored through a website.

Kalbuadi and Djatmiko focused on developing an innovative and environmentally friendly trash can, designed to address the increased waste production at home during the pandemic. These bins are designed by utilizing go- green principles and Internet of Things technology, making them an efficient solution for waste management. The design of this bin was developed using the Double Diamond design method to ensure a match with the user's needs. The result is an IoT- based eco bin design that is suitable for workspaces.

The system is designed to provide information when the bin is full, thus preventing waste accumulation and potential diseases. The research method used is qualitative design, creation, and testing that focuses on software function requirements. The results showed that this system is very helpful for Royalindo Residence housing cleaners, because the height of the garbage that exceeds the limit of the garbage can be detected and seen using a smartphone. Syahrir et al. designed an IoT-based tool called "TeMP" to address the problem of waste collection in Makassar. It uses a microcontroller-based ultrasonic sensor to detect when bins are almost full, allowing waste collectors to pick up waste in a more controlled manner. It can also detect the moisture of the waste, providing additional information useful for waste management. Setianingrum designed an IoT-based monitoring system with prediction features to improve waste management at Diponegoro University. The system is built on two nodes that measure the bin's occupancy rate, process the data, and send it to the database. The data is then processed using the Artificial Neural Network Levenberg Marquardt method to predict the height of the garbage in 2 hours. The test results show the average delay of sending data to the database is 2.886s and 2.912s with 0% packet loss. This model has an average square error rate of 8.96cm and 13.04cm in predicting the height of the garbage.

Bakhri et al. This study designed a garbage height detection system for Puseur Jaya Village, Karawang, with the aim of helping the Cleaning Service know when the trash can is full. This system uses the HC-SR04 sensor to monitor the height of the garbage in the container tub. The results show that this system can measure the height of the garbage accurately, with the value of the distance between the sensor and the garbage object changing according to the height of the garbage in the container. With this detection system, it is expected that the Cleanliness Service can be more efficient in managing waste transportation.

## Results and discussion

Based on the literature review, these studies can be classified into several categories based on the main focus of the research and the technology used. First, the development of IoT-based smart trash bins. This research focuses on the development of smart trash bins that use IoT to

monitor waste capacity and provide notifications to janitors when the bins are full. This includes research by Juwariyah, Ariessanti, Darmansyah, Ayutantri, Arsadi and Haryatmi, Citra, Febrianto, Syahrir, Setianingrum, Bakhri, Isnawaty, Roslan, and Alkautsar.

Furthermore, automatic waste separation focuses on developing systems that can automatically sort waste, either by material type (organic or inorganic) or by metal type. This research includes research by Surbhakti and Utomo. Then, methane gas detection which focuses on developing tools to detect methane gas produced by organic waste, which can cause respiratory distress and explosions.

The next group is the development of environmentally friendly trash bins that focuses on developing innovative and environmentally friendly trash bins, designed to cope with increased waste production at home during the pandemic. This research includes studies by Kalbuadi and Djatmiko. Lastly, community perceptions towards waste management which tries to understand community perceptions towards waste management and its effectiveness in areas with different topographies. This research was conducted by Udoyono and Abdulrohman.

From the above classification, it can be understood that IoT technology has been widely used in the development of smart bins to improve the efficiency of waste management. In addition, automatic waste separation has also become a major focus in several studies to ensure that waste can be properly sorted before disposal. In addition, methane gas detection is important in the context of organic waste management, while understanding the public's perception of waste management is also important to ensure the effectiveness of the waste management system. Based on the summarized research, a new theory called "Smart Waste Management Integration Theory" can be proposed. This theory focuses on the integration of various technologies and methods in waste management to create a more efficient and effective system. First, this theory emphasizes the importance of IoT integration in waste management. IoT allows real-time monitoring of bin capacity and provides notifications to cleaners when bins are full. However, the theory suggests that IoT can be used even further, such as to predict waste disposal patterns and optimize waste collection schedules.

Secondly, this theory emphasizes the importance of automated waste separation. While some research has already covered this aspect, this theory suggests that separation technologies can be further improved and customized for specific types of waste, such as electronic waste or medical waste. Third, the theory emphasizes the importance of methane gas detection and the use of alternative energy. By utilizing energy from the decomposition process of organic waste or kinetic energy from moving bin covers, a more sustainable waste management system can be created.

Fourth, this theory emphasizes the importance of understanding people's perceptions towards waste management. By understanding these perceptions, it can ensure that the waste management system is well received by the community and effective in practice. Finally, this theory emphasizes the importance of integrating smart bins with the city's overall waste management system. With this integration, a comprehensive waste management system can be created that is not only efficient but also has a positive impact on the environment and people's well-being.

With further exploration in these areas, the Smart Waste Management Integration Theory can assist in the development of more efficient and effective smart bins, as well as provide new insights into how technology can be used to address waste management issues. In addition, new

discoveries in these areas can also make important contributions to the scientific literature and waste management practices in the field.

Based on the research that has been summarized, there are several research areas that have not been explored in depth in the development of IoT-based smart trash bins. One of the unexplored areas is the use of AI and Machine Learning technology. Although several studies have used these technologies, there is still room for research on how AI and Machine Learning technologies can be used to predict waste disposal patterns and optimize waste collection schedules. In addition, these technologies can also be used to predict the type of waste to be disposed of based on previous patterns, which can help in the waste separation process.

Another unexplored area is the management of specific types of waste. Most research focuses on waste management in general. However, there is still room for research on the management of specific types of waste, such as electronic waste or medical waste, which require special handling. In addition, the integration of smart bins with the city's overall waste management system is also an unexplored area. Most research has focused on developing smart bins as standalone units. However, there is still room for research on how these smart bins can be integrated with the city's overall waste management system. Further exploration in these areas can help in the development of more efficient and effective smart bins. For example, by using AI and Machine Learning technology, a system can be created that can predict waste disposal patterns and optimize waste collection schedules, thereby improving the efficiency of waste management. In addition, by focusing on managing specific types of waste, it can ensure that each type of waste is managed in the most appropriate and safe way. Finally, by integrating smart bins with the city's overall waste management system, a comprehensive waste management system can be created that is not only efficient but also has a positive impact on the environment and people's well-being.

## Conclusion

The purpose of this article is to examine various IoT-based smart bin models, as well as their benefits and potential in waste management. Based on the summarized research, IoT technology has played an important role in the development of smart bins. This technology enables real-time monitoring of bin capacity and provides notifications to cleaners when bins are full. In addition, automatic waste segregation has also become a major focus in several studies to ensure that waste can be properly sorted before disposal.

However, there are still some research areas that have not been explored in depth. For example, the use of AI and machine learning technologies in the prediction of waste disposal patterns and optimization of waste collection schedules, the management of specific types of waste such as electronic waste or medical waste, and the integration of smart bins with the city's overall waste management system.

Further exploration in these areas can help in the development of more efficient and effective smart bins. For example, by using AI and machine learning technologies, systems can be created that can predict waste disposal patterns and optimize waste collection schedules, thereby improving waste management efficiency. In addition, by focusing on managing specific types of waste, it can ensure that each type of waste is managed in the most appropriate and safe way. Finally, by integrating smart bins with the city's overall waste management system, a comprehensive waste management system can be created that is not only efficient but also has a positive impact on the environment and people's well-being.

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