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Auralocular Autowastebin using IoT

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Abstract

As human intelligence continues to advance, so too does the sophistication of our everyday surroundings. The concept of Smart Cities has given rise to a demand for intelligent waste management solutions. Enter the concept of Smart Dustbins, tailored for deployment in Smart buildings, educational institutions, healthcare facilities, and public transit hubs. The Smart Dustbin represents an enhancement of the conventional waste receptacle, elevating it to a smart status through the integration of cutting-edge sensors and logical systems. The innovation behind Smart Dustbins lies in their ability to transform ordinary trash bins into intelligent entities. This is achieved by employing ultrasonic sensors for precise garbage level detection, coupled with a GSM module for real-time status updates to users. When a Smart Dustbin reaches full capacity, it triggers an automated Solid Waste Collection system to take action. One common issue with inadequately maintained traditional dustbins is the unsightly spillage of garbage in their vicinity. Such neglect can foster the proliferation of disease-carrying insects like mosquitoes, flies, bees, and driver ants. Moreover, the environment surrounding these bins can contribute to elevated levels of air pollution. Airborne pollutants stemming from a neglected dustbin can harbor harmful bacteria and viruses, posing severe health risks to humans. In conclusion, the integration of Smart Dustbins not only enhances waste management efficiency but also plays a crucial role in promoting cleaner and healthier urban environments.

***Keywords**: Raspberry Pi, GSM module, LCD Screen, Servo motor.*

1. Introduction

In the quest for sustainable urban development, the global waste management challenge persists, underscored by the visible consequences of overflowing garbage bins in cities worldwide. Beyond the aesthetic concerns, these overflowing bins pose threats to public health and the environment, making effective waste management a pressing need on a global scale. The smart city concept in India, epitomized by the ambitious plan to establish 100 smart cities, signals a paradigm shift in urban planning. Within this framework, the attention given to waste management highlights the recognition of its pivotal role in creating urban environments that are both technologically advanced and environmentally conscious. Smart Dustbins, a key element of this initiative, represent a strategic upgrade from conventional waste disposal methods. The significance of Smart Dustbins lies in their ability to transcend the limitations of traditional bins. Equipped with sophisticated sensors and communication technology, these intelligent bins proactively signal when they approach capacity, streamlining waste collection processes. Beyond their technological prowess, Smart Dustbins stand as symbols of progress in waste management, aligning with the overarching objectives of smart cities. They contribute not only to the visual appeal of urban spaces but also actively mitigate health risks and environmental hazards associated with poorly managed waste. As catalysts for change, Smart Dustbins exemplify how technological innovation can address age-old urban challenges. Their integration into the urban landscape signifies a commitment to sustainable practices, setting the stage for cleaner, more efficient, and healthier cities. In essence, Smart Dustbins transcend their functional role, becoming integral components in the realization of a forward-looking vision for urban living that prioritizes environmental sustainability and the well-being of communities. The smart city initiative in India, with its emphasis on technological integration and efficiency, acknowledges the intrinsic link between waste management and the overall well-being of urban communities. Amidst the rapid development of smart cities, the role of Smart Dustbins becomes increasingly pivotal. In the broader context, Smart Dustbins symbolize a paradigm shift towards holistic urban planning, where technological innovation is harnessed to address fundamental challenges. As they become an integral part of the urban fabric, these intelligent bins pave the way for a future where cities are not just smart in terms of infrastructure but are also characterized by a harmonious relationship with the environment. In conclusion, Smart Dustbins represent a trans-formative force, transcending traditional waste management approaches and embodying a vision of urban living that is sustainable, resilient, and responsive to the evolving needs of our globalized society.

2. Literature Survey

[1]. K. Hari krishna1, M. Vineetha Kumari2, M. Priyanka3, K. Hymavathi4T. Vamsi Mohan5 proposed The IoT Garbage Monitoring System simplifies waste management by using a Raspberry Pi Pico and Ultrasonic Range Finder Sensors to measure bin levels. It includes a buzzer for full-bin alerts and offers remote monitoring through IoT technology, making garbage management more efficient and convenient.

[2]. Swati Sharma*1 Sarabjit Singh (May 2018) proposed a Smart Dustbin Management System that combines IoT hardware with the Ionic framework for efficient waste management. When a dustbin reaches maximum capacity, it triggers cleaning. If not cleaned promptly, reports go to administrators for action. Sensors like PIR, IR, and APR modules detect motion, control bin gates, and process data. The system also includes a shoe polishing feature using IR sensors and a DC motor.

[3]. 1twinkle Sinha, 2k. Mukesh Kumar, 3p. Saisharan (5, May 2015) proposed Smart Dustbins play a pivotal role in curbing roadside garbage buildup, effectively mitigating the spread of diseases. They also act as a barrier against pollution and deter street animals from scavenging scattered refuse. In the grander context of building smart cities, these intelligent waste bins make a significant contribution to fostering a clean and hygienic urban environment.

[4]. 1. Fady E. F. Samann(28 June 2018.) proposed The system is built upon the Arduino Nano board and employs an ultrasonic sensor to constantly monitor the container's fill level, sending SMS alerts through a GSM module when needed. Power is supplied by a lithium battery power bank, which is supplemented by a solar cell panel for sustainability. Notably, this system offers the convenience of charging external portable devices through the power bank. Additionally, it records usage events via a PIR sensor and tracks container fullness events, storing this data on a memory card. The memory card also facilitates the playback of audio messages via a speaker during bin utilization. Overall, the system was successfully implemented at a reasonable cost, and its performance met the expected standards based on test results.

[5]. U. Nagaraju, Ritu Mishra, Chaitanya Kumar, Rajkumar (06 May 2017). In recent decades, urbanization has witnessed a remarkable surge, accompanied by a parallel increase in the demand for innovative solutions to address the evolving challenges of modern city living.

[6]. Chinmay Kolhatkar, Bhavesh Joshi, Prachi Choudhari, and Dhruvin Bhuva (3 Jan 2018) proposed in addressing India's waste management challenges, this study delves into the inadequacies of current systems and highlights the critical role of smart city concepts. The literature survey introduces a novel approach, utilizing IoT protocols and the Espresso chip, to transform urban waste management, focusing on the enhancement of the traditional dustbin with real-time status transmission and obstacle detection features. Table 1. shows the Literature Survey for Auralocular Autowastebin using IoT.

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Table 1. Literature Survey for Auralocular Autowastebin using IoT

Authors	Issues	Techniqu esused	Environment and mode	Remarks
Andi Muhammad Saad et al. {1} 2023	Accompanied by the management of waste transformation so that the accumulation of that waste can be prevented.	IOT, Sensors, Sensor lead cell, module GPS, Arduino Nano.	Hardware and software, environment, development environment Mode: Operational and communication mode.	software design shows it function well in sending a full dustbin notifications message containing the longitude and latitude values of the dustbin location via the Twilio web to WhatsApp.
Dr. Thiyaneshwar an Balashanmug am et al. {2} 2021	To check the dustbin is full or not and waste level of the trash bin.	IOT, Node,MCU, IFTTT web books	Hardware and software environment Mode: Operational mode.	By using this system to find a minimum height of a rubbish in a dustbin that is placed in it. It helps to keep environment clean and without causing any kind of disease.
NABANEETA BANERJEE et al. {3} 2022	Integration of some hardware components is done for more efficient use ofit.	ARDUINO IDE, UNO BOARD, SERVO MOTOR.	Hardware and Software Mode: Operational mode.	By this project, the lid of the dustbin stays closed so that waste is not exposed.
Jeniper Prarthana et al. {4} 2016	To develop a smart intelligent garbage alert	Embedded system, RFLO, ARDUINO sensor.	Hardware and Software Mode: Operational and communication mode.	This system averts the irregular cleaning of dustbin by sending alerts to the concerned individual at regular interval.
Saniya Mupram Ansari et al. {5} 2019	It offers an easy< reliable solution to the problems of inefficient garbage disposal faced.	Gas sensor, PIR sensor, DC motors.	Hardware and Software Mode: Operational.	This system assures the cleaning of dustbin when the garbage level reached its maximum this rescued number of trips of garbage collection vehicle and reduced expenditure.
Anuradh a Singh et al. {6} 2021	Develop an intelligent waste alert system collection by the sending a notification to a municipality web application immediate dustbin clear and a notification to waste pill levels.	Buzzer IOT, GSM, Blynk App, wifi modules.	Hardware and software Mode: Operational and communication mode.	This technology reduced human work while simultaneously making the surrounding more environment friendly.
Mitali Pingle et al. {7} 2020	Issues are in urban cities solid waste management. Greater access to garbage disposing point.	ESP82 Microcontroller , Buzzer, Bread Boards, Ultrasonic sensor.	Hardware and software environment Mode: Operational.	It improves the system additionally endorsing the states of cleaning in real time and measure the performance of the team.
Esthee Rai et al. {8} 2022	This will help in monitor thetrash collected in the dustbin, this alerts the users via buzzer that the bin is full and need to emptied.	ESP82 Microcontroller , Buzzer, Bread Boards, Ultrasonic sensor.	Hardware and software environment Mode: Operational.	It Is emerging technology that is utilized for monitoring the garbage.

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3. System Design

3.1 Ultrasonic Sensor

Ultrasonic sensors are being used to measure the level of waste in the dustbin. Ultrasonic waves are used by these sensors to detect the space left between the sensors and the uppermost surface of waste, which helps in real-time monitoring of waste levels in the dustbin [7].

3.2 Proximity Sensors for Waste Detection

Proximity Sensors, like infrared sensors are used to check the waste present in the dustbin. These Sensors are used to monitor when the waste is nearby or close, which allows the system to differentiate between blank and preoccupied space or better collection data.

3.3 Raspberry Pi

Raspberry Pi is used to process the data from both the ultra-sonic sensor and proximity sensors to help in efficient decision-making based on already-defined algorithms. It is flexible as it has multiple options for connectivity, providing appropriate choices for the functioning of the multiple components of the dustbin system.

3.4 Display User Interface

The smart dustbin has a display that gives us real-time data on the segregation of waste with the help of interactive graphics users can identify and monitor the segregation status, which ensures an environmentally suitable waste disposal experience.

3.5 Connectivity - Wi-Fi Module

A Wi-Fi module is fitted in this dustbin to enable seamless internet connectivity. The Internet connectivity helps in transferring data to a central server in real-time, which enhances remote monitoring and management of the waste disposal system.

3.6 Power Supply

The dustbin uses solar charges as an alternate source in its power supply system. This alternate approach helps in harnessing solar energy to recharge the batteries used in the dustbin system, which contributes to longer and more eco–friendly operational abilities.

3.7 System Architecture

Figure 1 shows our system architecture

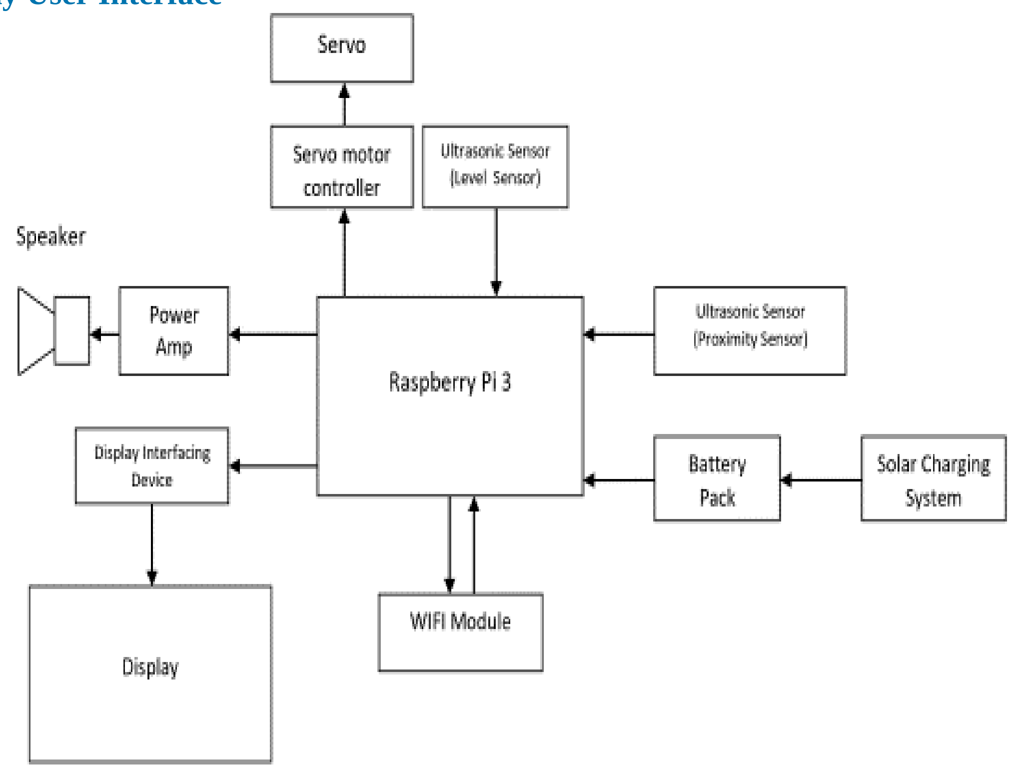

Figure 1 System Architecture

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4. Objective

The primary objective of this project is to revolutionize urban waste management by developing and implementing an advanced smart dustbin system that incorporates a 32-inch LCD screen. This multifaceted system is designed to accomplish the following overarching goals:

- **Enhanced Waste Segregation:** The core aim is to facilitate efficient waste segregation within urban environments. By employing a large, user-friendly LCD screen, we seek to encourage residents, visitors, and commuters to actively participate in the waste sorting process.
- **Environmental Education and Awareness:** Through the dynamic display of visually engaging content and audio messages, the system will serve as an educational tool, raising environmental awareness and promoting responsible waste disposal practices. It will convey the significance of recycling, composting, and waste reduction, fostering a culture of sustainability.
- **Revenue Generation and Sustainability:** An integral part of this initiative is to explore potential revenue streams by partnering with local businesses and organizations for advertising space on the LCD screen. This generated income will be reinvested to ensure the sustainability, maintenance, and expansion of the smart dustbin network.
- **User Engagement and Empowerment:** The project envisions fostering user engagement by incorporating interactive features within the LCD screen interface. It will provide real-time information about nearby recycling centers, waste collection schedules, and eco-friendly initiatives, empowering individuals to make informed choices [8].
- **Durability and Energy Efficiency:** To guarantee long-term viability, the system will prioritize durability and weather resistance of all components, particularly the 32-inch LCD screen, which will be exposed to outdoor elements. Moreover, the project will embrace sustainable practices by harnessing renewable energy sources, such as solar panels, to power the system, thereby reducing its environmental footprint.

5. Methodology

a) User Presence Detection

When an individual approaches the smart dustbin, the ultrasonic sensor detects their presence.

b) Signal Processing

Used a Raspberry Pi to process the data from the sensor in real time.

c) Automatic Lid Opening

Used a Raspberry Pi to process the data from the sensor in real time.

d) Fill Level

When an individual approaches the smart dustbin, the ultrasonic sensor detects their presence.

e) Threshold Evaluation

Raspberry Pi fill level surpasses a predefined threshold, and the system promptly triggers the audio component to emit audible alerts.

f) Audio and Visual Alerts

Concurrently, the 32-inch LCD screen on the dustbin's exterior comes to life, displaying pertinent messages and information related to responsible waste disposal practices and showcasing advertisements

g) Communication Module

The system ensures proactive communication by dis-patching SMS alerts via the GSM module to designated recipients, ensuring swift attention to the full bin.

h) Power Source and Sustainability

The comprehensive approach, underpinned by sustainable power sources like the battery recharged by the solar charger,

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delivers a highly integrated and effective waste management solution.

i) Continuous Enhancements

By enhancements, the smart dustbin can evolve into a dynamic and integral component of a smart city's waste management and sustainability initiatives, further enhancing its capabilities and impact on urban living.

j) Hardware Design

- **Raspberry Pi 4:** The core component of the hardware design for the smart dustbin is the Raspberry Pi 4. Chosen for its computational power and versatility, the Raspberry Pi 4 serves as the central processing unit responsible for data analysis, decision-making, and overall system control. It interfaces with various peripherals, ensuring seamless integration of the smart dustbin's functionalities.
- **Ultrasonic Sensor:** The ultrasonic sensor is employed for detecting the presence of users in proximity to the smart dustbin. This sensor plays a pivotal role in initiating the automatic lid-opening mechanism, enhancing the overall user experience. Connected to the Raspberry Pi, the ultrasonic sensor provides real-time data, enabling the system to respond promptly to user interactions.
- **Servo Motor:** The servo motor is an integral part of the hardware, responsible for the controlled movement of the dustbin's lid. Connected to the Raspberry Pi, it executes commands based on the system's decision-making algorithms. The servo motor ensures smooth and precise lid manipulation, enabling the dustbin to transition between open and closed states as required.
- **Display:** The visual component of the smart dust- bin is realized through a 32-inch LCD screen. This display serves multiple purposes, including presenting information about responsible waste disposal practices, showcasing advertisements, and providing visual alerts. Connected to the Raspberry Pi, the display is controlled dynamically based on user interactions and system feedback.
- **Speaker:** For auditory alerts and user engagement, an audio component in the form of a speaker is integrated. Connected to the Raspberry Pi, the speaker emits audible alerts when the dustbin's fill level surpasses a predefined threshold. Additionally, it contributes to the user-friendly nature of the smart dustbin by providing real-time feedback and guidance.
- **Regulator and Rectifier:** To maintain stable voltage levels and protect sensitive components from power fluctuations, a voltage regulator is incorporated into the hardware design. Conversely, the rectifier converts alternating current (AC) from the power source into direct current (DC), ensuring compatibility with the electronic components used in the system. Together, the regulator and rectifier contribute to the reliability and longevity of the smart dustbin.
- **Power Supply:** A reliable and efficient power supply is crucial for the continuous operation of the smart dustbin. A rechargeable battery, charged through a solar charger, serves as the primary power source. This sustainable approach ensures autonomy and reduces reliance on external power grids. Additionally, a voltage regulator is employed to stabilize the power input and ensure consistent and safe operation of the entire system [9]. The Hardware Design of Smart Dustbin is shown in Figure 2.

6. Result

The findings from our evaluation underscore the compelling success of the audio-visual smart dustbin, seamlessly integrating technological innovation with pragmatic functionality. This harmonious fusion results in a holistic and efficient waste management solution tailored to the dynamic landscape of smart city environments. Notably, the system excels in engaging users through its user-friendly interface. Moreover, the real-time alert features of the smart dustbin emerge as a key

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strength, providing timely notifications to both users and collecting authorities. This not only enhances the overall efficiency of the waste collection but also contributes significantly to the timely addressing of potential issues such as overflowing bins or maintenance requirements. By incorporating sustainable practices, such as optimized energy consumption and materials recycling, the smart dustbin aligns itself with the broader goals of environmental preservation and resource efficiency, marking it as a conscientious contributor to urban living. The audio-visual smart dustbin stands as a valuable asset in urban development, addressing waste management pragmatically while symbolizing the transformative power of technology for cleaner, smarter, and sustainable cities. In the evolving urban landscape, such innovative solutions play a pivotal role in shaping the future of urban living and waste management practices. The Hardware Design of Auralocular Wastebin result is shown in Figure 3.

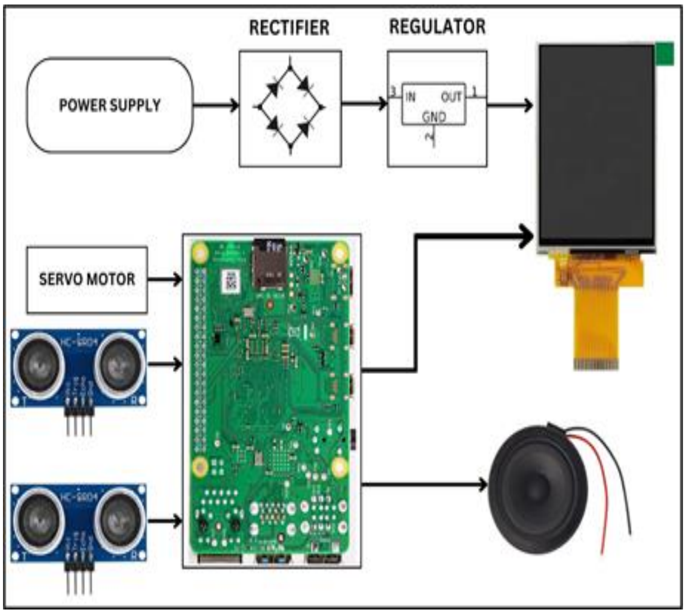

Figure 2 **Hardware Design of Smart Dustbin**

6.1 Prototype

Figure 4 reveals the Auralocular Dustbin, featuring a 32-inch LCD screen and a dual-compartment system for wet and dry waste, revolutionizing waste management, promoting transparency, education, and efficient segregation in a single, integrated solution. This cutting-edge waste management solution not only enhances user engagement through its dynamic LCD interface but also underscores its commitment to sustainability by streamlining waste segregation practices. In just one graph, the Auralocular Dustbin encapsulates the convergence of technology and environmental responsibility, ushering in a new era of informed and eco-conscious waste disposal in urban environments.

Figure 3 **Hardware Design of Auralocular Wastebin**

6.2 Testing Results

In this evaluation, the responsiveness of the dustbin lid is intricately tied to the specific testing distances in centimeters. Notably, when the testing distance falls within the 50 cm threshold or below, the lid demonstrates an opening mechanism at precise intervals of 10 cm, encompassing distances of 10 cm, 20 cm, 30 cm, 40 cm, and 50 cm. On the contrary, when the testing distance surpasses the 50 cm mark, the lid consistently remains in a closed position, maintaining this status for distances spanning from 51 cm to 100 cm. This operational distinction caters to a nuanced and adaptive functionality, ensuring optimal lid control across varying proximity scenarios, as illustrated in the comprehensive Table 2. The chart illustrates the

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testing results of a smart dustbin at various defined distances. The testing distances, measured in centimeters, range from 10 cm to 100 cm. The corresponding output of the smart dustbin is categorized into "Open" and "Closed."

Table 2 Test result for opening dustbin lids

Defined distance (cm)	Testing Distance (cm)	Output
≤ 50	10	Open
≤ 50	20	Open
≤ 50	30	Open
≤ 50	40	Open
≤ 50	50	Open
≤ 50	60	Closed
≤ 50	70	Closed
≤ 50	80	Closed
≤ 50	90	Closed
≤ 50	100	Closed

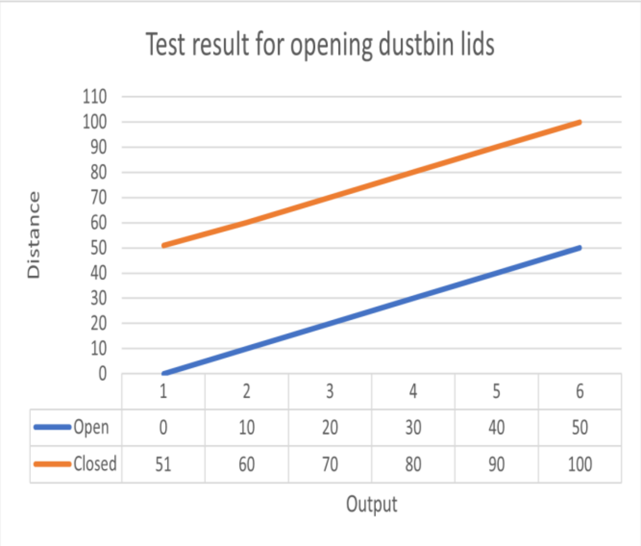

Figure 4 Testing result chart

7. Future Enhancement

In future iterations, we can expand the model's capabilities by incorporating advanced route optimization algorithms, leveraging real-time traffic data and machine learning to dynamically adapt collection routes based on current conditions. This adaptive approach ensures continuous efficiency in waste management operations. To address environmental concerns, we may explore integrating eco-friendly vehicles and renewable energy sources to power the waste collection fleet. This not only aligns with sustainability goals but also contributes to reducing the overall carbon footprint of waste management activities. Continued research and development in these directions not only improve the efficiency of waste collection and transportation but also contribute significantly to creating a more sustainable and environmentally conscious waste management system for the future [10].

Conclusion

The Auralocular Autowastebin is meticulously crafted for the streamlined collection and effective management of waste. This innovative dustbin sends a prompt notification to the cleaning authority when it reaches 80% capacity, proactively preventing overflow issues. The data gleaned from bin fill-ups serves a dual purpose, not only aiding in timely waste removal but also guiding the strategic placement of these bins in high-traffic waste generation areas. Equipped with an auto-open and close feature, this dustbin ensures a non-contact, closed system, effectively containing unpleasant odors. The inclusion of a screen adds a modern touch, enabling the dissemination of awareness through engaging visuals, surpassing the traditional noticeboard approach. Designed with a commitment to environmental improvement, the Auralocular Autowastebin embodies a vision of fostering a better and healthier environment through its multifaceted features and conscientious design.

Discussion

The research highlights a disorganized and inefficient placement of dustbins, posing a challenge for collecting authorities due to the absence of a defined route map. This results in excessive vehicle usage, leading to heightened carbon emissions detrimental to the environment. A simple shift from using two vehicles to one could potentially slash carbon emissions by 50%, presenting a significant reduction in environmental impact during waste collection. Furthermore, the study reveals a prevalent issue of overflowing dustbins causing foul smells and pollution. The lack of real-time monitoring mechanisms forces collecting authorities to physically inspect each bin, a time-consuming process. Implementing an automated system that alerts authorities before bins reach full capacity could effectively address the problem of overflowing bins, streamlining waste management operations and promoting a cleaner and healthier environment.

Acknowledgment

In the pursuit of our research, we wish to convey our deepest thanks to Mr. Arun Rai, an esteemed professor at GNIOT, Greater Noida. His unwavering guidance and mentorship have played a pivotal role in shaping the trajectory of our research endeavors. We are also indebted to the dedicated members of CPRC, and GNIOT, whose collaborative efforts, insightful inputs, and unwavering support have been instrumental throughout the entire research process. Their collective commitment to academic excellence and research enhancement has significantly enriched our experience and contributed to the successful culmination of this project. Our sincere appreciation goes out to everyone who has been part of this journey, and we are truly grateful for their invaluable contributions.

References

[1]. Dr.Thiyaneswaran Balashanmugam. IoT-based smart dustbin. Annals of the Romanian Society for Cell Biology, 25:7834 – 7840, 03 2021.

[2]. R Prem Chand, V Bavya Sri, P Maha Lakshmi, S Santosh Chakravathi, ODM Veerendra, and Ch Venkateswara Rao. Arduino-based smart dust-bin for waste management during COVID-19. In 2021 5th International Conference on Electronics, Communication and Aerospace Technology (ICECA), pages 492–496. IEEE, 2021.

[3]. Varun Chaudhary, Rohit Kumar, Anil Rajput, Manvendra Singh, and Thakurendra Singh. Smart dustbin. International Research Journal of Engineering and Technology, 6(05):2395–0056, 2019.

[4]. Chinmay Kolhatkar, Bhavesh Joshi, Prachi Choudhari, and Dhruvin Bhuva. Smart e-dustbin. In 2018 International Conference on Smart City and Emerging Technology (ICSCET), pages 1–3, Jan 2018.

[5]. PG Kuppusamy, K Prathyusha, P Prasad, V Rasagna, N Sasi Eswar Reddy, and N Purushotham. Smart dustbin using RFID reader.

[6]. B Rajapandian, K Madhanamohan, T Tamilselvi, and R Prithiga. Smart dustbin. International Journal of Engineering and Advanced Technology (IJEAT), 8(6):4790–4795, 2019.

[7]. Kannapiran Selvaraj and Arvind Chakrapani. Smart dustbin monitoring system using LAN server and Arduino. International Journal of Advances in Computer and Electronics Engineering, 2(4):20–23, 2017.

[8]. Farzana Shaikh, Nagma Kazi, Farheen Khan, and Zaid Thakur. Waste profiling and analysis using machine learning. In 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA), pages 488–492, July 2020.

[9]. Aayush Tripathi, Chinmay Pandey, Ankur Narwal, and Devashish Negi. Cloud-based smart dustbin system for the metro station. In 2018 3rd International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU), pages 1–4, 2018.

[10]. Cheah Wai Zhao, Jayanand Jegatheesan, and Son Chee Loon. Exploring IoT applications using Raspberry Pi. International Journal of Computer Networks and Applications, 2(1):27–34, 2015.