Hindawi
Advances in Materials Science and Engineering
Volume 2022, Article ID 1598868, 7 pages
https://doi.org/10.1155/2022/1598868

Research Article

Plastic Waste Management System Using Metal Shredder for Clean Environment

C. Jeyalakshmi,[1] **Manjunathan Alagarsamy**,[1] **R. Kalaiarasan**,[2] **M. Easwaran**,[3] **Yuvaraja Thangavel**,[4] **and Prabhu Paramasivam**[5]

[1]*Department of Electronics and Communication Engineering, K. Ramakrishnan College of Engineering, Trichy, Tamil Nadu, India*
[2]*Department of Electronics and Communication Engineering, M. Kumarasamy College of Engineering, Karur, Tamil Nadu, India*
[3]*Department of Electronics and Communication Engineering, Sastra University, Tanjore, Tamilnadu, India*
[4]*Department of Electronics and Communication Engineering, Kongunadu College of Engineering and Technology, Trichy, Tamilnadu, India*
[5]*Department of Mechanical Engineering, College of Engineering and Technology, Mettu University, Mettu 318, Ethiopia*

Correspondence should be addressed to Prabhu Paramasivam; drprabhu@meu.edu.et

Received 7 June 2022; Accepted 20 July 2022; Published 16 August 2022

Academic Editor: Pudhupalayam Muthukutti Gopal

With the high rise in population and a huge level of unwanted materials, conventional methods of waste disposal are becoming outdated as it involves more manual scavenging work and unwanted human potential. In order to overcome the above manual issues, there is a need to design a machine that can clear the litter and leftover wastes without much involvement of human indulgence. To overcome the above issues, the smart garbage collector was designed and implemented. It consists of a vacuum machine that sucks out leftover trash on the ground. Then, it is lifted to a certain height by servo motors to drop it into the shredding area. The shredder then cuts the waste into very tiny pieces. Then, the waste pieces are transferred to the storage box. This box is placed at an inclined angle to support the disposal of waste without human intervention. The box opening and closing actions are controlled by a servo motor that is placed outside the box and the slide opens vertically to avoid any unwanted residual waste in the storage box. The storage box consists of an ultrasonic sensor to notify the level of waste accumulated inside the box, and when the maximum threshold value is attained, the proposed machine has to dispose of the crushed waste. All the actions of the controller are monitored by a private server hosted on the Blynk platform that can be accessed only by the user. The server can be controlled through a mobile interface that acts as a remote control for the proposed machine. The Local Server is set up using Raspberrypi which enables ease of access to the Blynk server hosted in our home router IP.

1. Introduction

Currently, plastic waste crushers are available in many places, but they are large sized and their usage is best suited for waste processing centers or public places such as railway stations, malls, busy places, and so on. Although effective in plastic waste management, such crushers primarily serve the purpose of recycling the plastic waste that has been manually collected and brought to waste processing centers. For closed-area waste management, their effectiveness is limited because of their costly, bulky nature as well as maintenance requirements. Moreover, if there is no manual labor to collect and deposit waste due to a lack of resources, it presents a cleanliness hazard to the nearby environment.

Already portable waste bottle crusher is designed [1] but it is not moveable and we cannot control it with our mobile phone. For an efficient, affordable solution for plastic waste management in small spaces, a miniature low-cost mobile crusher will be the ideal option, and in this paper, we aim to design a prototype mobile crusher robot that will have the main features of reduced cost, small in size, and move in any direction with user friendly in maintaining plastic wastes. Hence, it provides an attractive design for waste collection in domestic areas. Many problems are arising due to plastics

even for the sea creatures like fish. Though our government is banning one-time use of plastic bags, most countries have made official announcements and warnings, to control the pollution caused by plastic materials.

So, this compact mobile crusher robot will be very valuable to society because of its affordable costs, autonomous functioning, and prevention of manual collection of waste thereby promoting a clean environment. At the national level, in India, used PET bottles are recycled into other useful products like polyester fibers which will be utilized in textiles. The Indian government is now keen on eliminating all single-use plastics from our country by 2022. At present, a common way to recycle plastic waste is mechanical recycling [2] only. At the International level, a documentary on National Geographic depicted a report [3] highlighting plastic waste; only 9% of the plastic has been recycled.

In India, the foremost thing is, in metropolitan cities and in small towns, we have to Install solid waste recycling units [4]. Types of solid plastic waste (SPW) and their origins are discussed [5]. Indian Railways [6] installed a 'PET bottle crushing machine' at many railway stations to minimize plastic waste. The railway authorities announced that if a passenger drops a bottle into the machine, they will avail of a cashback of Rs. 5 in their Paytm accounts. In this paper, we have designed a low-cost machine for a plastic waste crusher that can be utilized for recycling. There are so many products that are also there in the market designed by other inventors which are discussed here.

Once the dustbin is filled, immediately an interrupt signal is sent to a controller which switches on the moving system using RFID tags. And once it is activated, the current system stops and automatically the servo system starts its function to dispose of the collected waste material in some other place [7]. We know that GSM is advantage over ZigBee for short-range communication; here, author [8] uses GSM MODEM, and they used an Infrared (IR) sensor for garbage detection. Another smart bin [9] consists of observing the level of the bin, and it will automatically dispose the waste in the prescribed area and back to its original place. This automatic bin also contains a gas sensor to alarm the nearby people if harmful gas leaks. Multiple dustbins [10] from the various places of the city are connected through IOT. A mathematical formulation technique is introduced to maintain the whole system.

The work related to the current system [11] which was referred in this paper emphasis on dynamic models for collecting unwanted materials. Based on fuzzy credibility theory, the model is created. The author's [12] aim is to achieve a centralized real-time management system. Both the municipal and the residents thus benefit from an integrated program resulting in substantial cost savings and less urban emissions. The planned system would be able to simplify the cycle of solid waste disposal and the monitoring of the total collection method utilizing the IoT. In this paper [13], authors introduced 2 routing methods so as to fulfill solid waste disposal in a smart city. For detecting the level of the garbage, IR sensors are used in this [14] system. The pH sensor is also utilized to detect degradable or nondegradable material. Every such dustbin [15] is provided with a light sensor part at several distances from the base of the dustbin. Hence, as soon as the bin is completely filled, the GCV comes and such that there is no chance for spillage. In this paper [16], author has designed an electronic model to empty the bin as soon as it is filled. Hence, the waste can be managed efficiently using the proposed system. To manage the waste problem, IOT-based approach is proposed [17] by the author. To connect the sensor and the IOT module, an advanced microcontroller is utilized as a visual connecting device. This is also implemented in the native village of the author.

In order to overcome the difficulties such as the absence of channelization of collected waste and a mechanism to separate waste, in this paper, we proposed a wirelessly controlled garbage collector that operates only through a private server hosted in Raspberry Pi by using the Blynk controlling software. All the commands to the microcontroller are sent through the mobile user interface. The trash is sucked out by using a vacuum, and the servo motors navigate it to the crusher where the trash is crushed to fine pieces and dropped into the storage chamber beneath the board. The storage chamber consists of a sensor to monitor the level of trash accumulated in the storage and consists of a servo motor to open and close the cover of the chamber to get out the trash. The collector transports by 4 DC motors controlled by a motor driver given a power supply by 12 V batteries. The Smart Garbage Collector can be used in places of mass waste gathering such as railway stations, malls, and theatres.

2. Design Methodology and Implementation

Figure 1 shows the process diagram of the current device using an Arduino microcontroller. Initially, the plastic bottles are sucked by the garbage suction, and for this, most of the power is needed. These wastes are crushed in the shredder section and collected in the storage section. A plastic shredder shown in Figure 2 is a mechanical device that is used to cut the plastic into small pieces for recycling process. It consists of numerous steel blades which are capable of cutting the plastic pieces. There are two shafts structure in it. Each shaft consists of an equal number of blades in it. Both the shafts rotate towards them or away from them. The blades are correctly fixed perfectly so that they will not strike each other. The shafts are controlled by the AC motor. We power the motor using a single-phase AC power supply (240 V–50/60 Hz). Using many gears, the shafts and motor will be connected. In general, the shredding method produces raw material to be utilized further for manufacturing, at the same time finished products like landscape protection. Distinct terms are used to define size reduction devices, such as grinders, chippers, granulators, and hammer mills. The main motto is to reduce the size of the given input material.

Any automated system makes use of a microcontroller or digital signal processor to control the real-time signals received from the inputs. It is converted into appropriate data and controlled accordingly. The microcontroller used in this investigation is Arduino uno which is clearly shown in

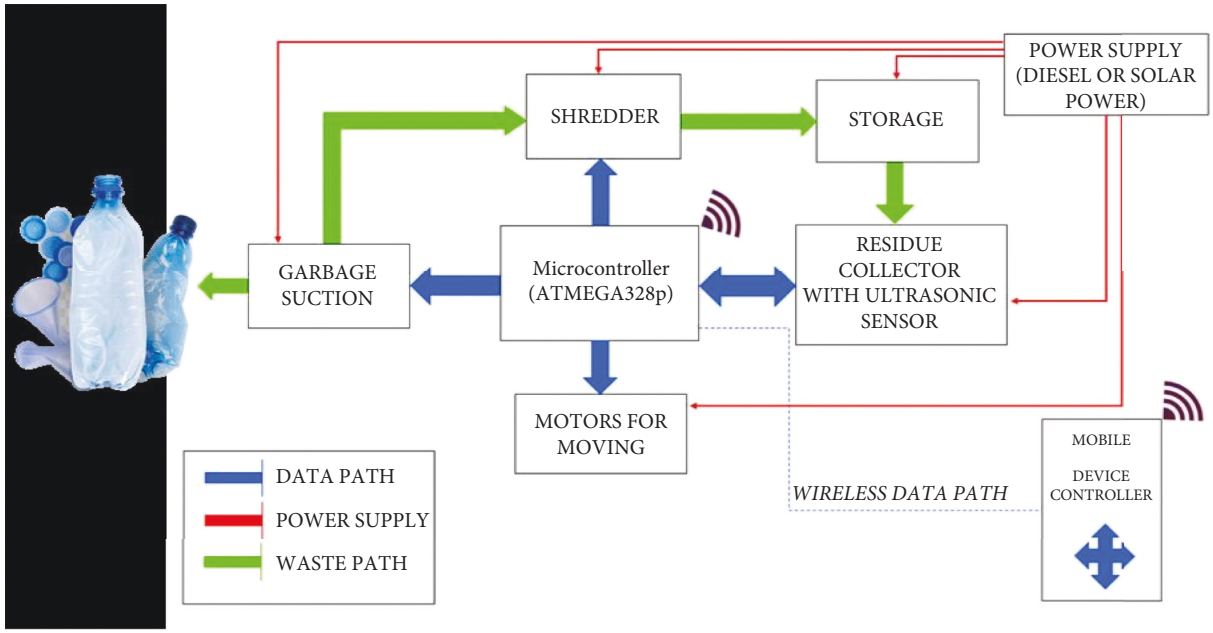

Figure 1: General process diagram of the smart garbage collector.

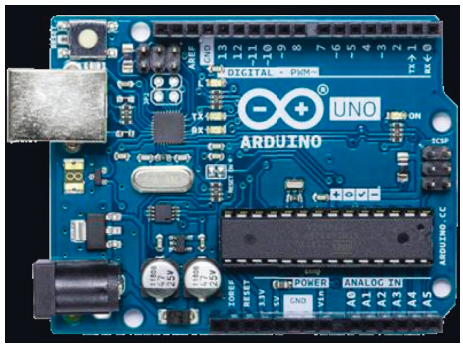

Figure 2: Front view of the shredder.

Figure 3 and has fourteen input and output pins. Out of these fourteen pins, six are utilized as pulse width modulated outputs, and six can be used as analog inputs. This board also contains a sixteen megahertz ceramic resonator, a universal serial bus connection, and a provision for reset function. In this Arduino board, there are two receivers and transmitter Light Emitting Diodes which can be flashed when required. i.e., when internally when data are transmitted via the USB to the serial chip and from the USB to the computer system. Through the Arduino digital pins, serial communication is made possible through the software serial library. It also supports the interintegrated circuit and serial peripheral interface protocol for serial data transfer. As we know, IIC is slower than SPI since it uses four wire protocols for data transfer.

Another microcontroller unit shown in Figure 4 is ESP8266 which can be automatically controlled through our local Wi-Fi network or from the Internet. The above ESP-01 module has general purpose input and output pins which will be suitably programmed to operate an LED or a relay via the Internet. The module will be programmed by an Arduino USB to TTL converter via the serial pins. The ESP8266 module works with 3.3 V only so that higher than this supply will damage the circuit.

Blynk shown in Figure 5 is a new platform that allows us to quickly build interfaces for controlling and monitoring our hardware projects from our iOS and Android device. After downloading the Blynk app, we can create a project dashboard and arrange buttons, sliders, graphs, and other widgets onto the screen. Using the widgets, we can turn pins on and off or display data from sensors. Blynk supports hardware platforms such as Arduino, Raspberry Pi, and similar microcontroller boards to build hardware for our projects.

The user mobile controller and the garbage collector will be connected to the same network. A private server is created using the desired microprocessor (Raspberry pi). The Raspberry pi will act as the private domain of the server (local server). We can also use a separate mobile application in order to give the control signals to the garbage collector. Once the garbage is detected by the user, they send the control signal from the mobile controller to this waste crusher unit using the desired mobile application. The signal will be detected by the transceiver module in the garbage collector. First, the user will send the moving commands to the crusher to move to the desired position and send the control signal for the movable handle which carries the suction pipe. The handle will move downwards making the suction pipe nearer to the garbage. Then, the user will send the control signal for the suction module such that the garbage will get stacked to the mouth of the suction pipe. By sending the signal to the suction pipe, the garbage will correctly fall in the area of the shredder. The shredder will be activated by the user control, such that it will move in a forward direction so that the garbage will be cut into small pieces. The output of the garbage will get

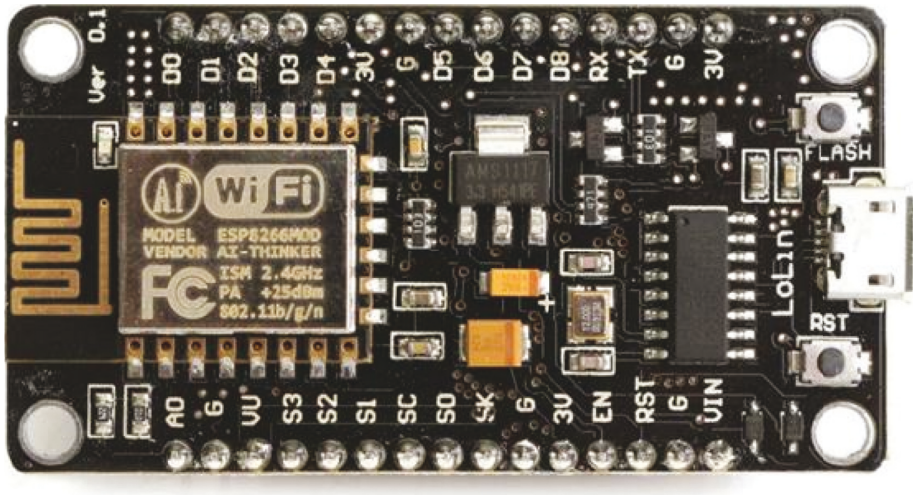

Figure 3: Arduino board.

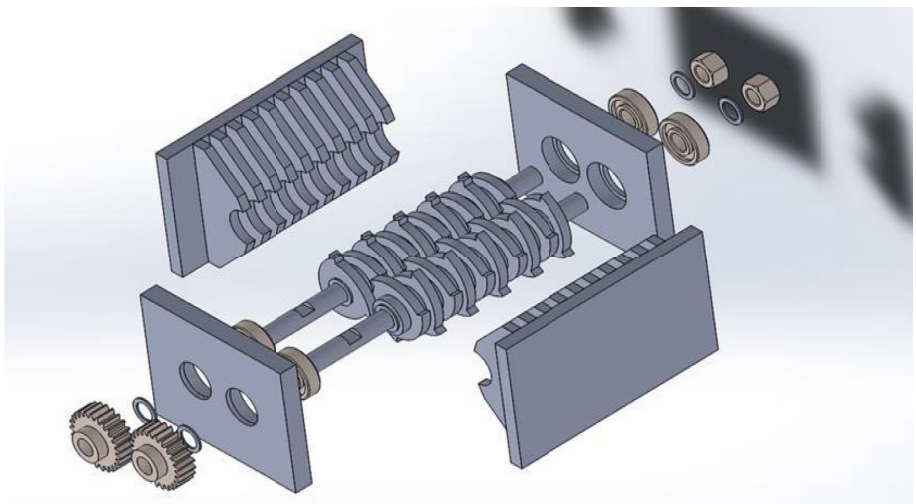

Figure 4: Node MCU ESP8266.

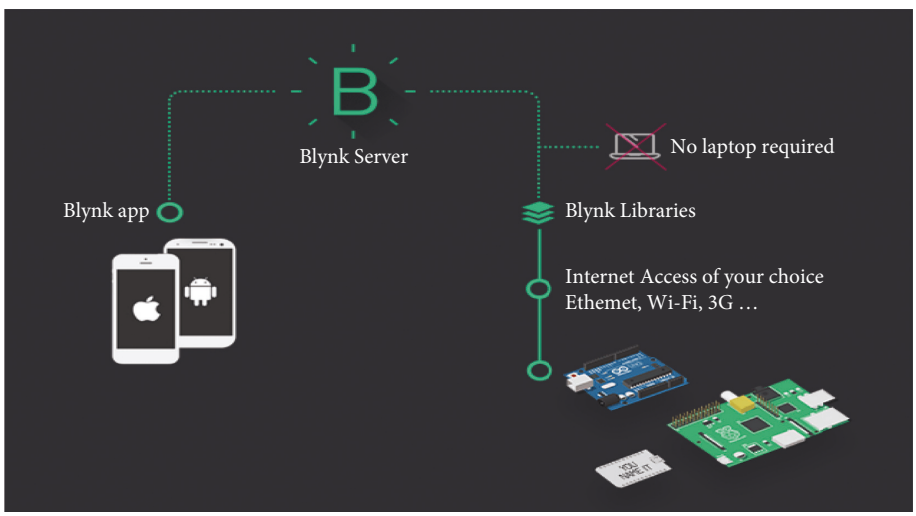

Figure 5: Front panel of Blynk app.

Figure 6: Suitable materials for crushing.

stored in the waste storage box below the crusher unit. Hence, our main motto will be completed. Once the waste storage box will get filled, the user will get a notification on the mobile device because we have employed an ultrasonic sensor in the waste storage box. So, the user can give the control signal to the waste storage box lid, which will be controlled by the servo motor. So that the lid will open and the wastes will fall outside, especially in the recyclable area. Then, the waste will be recycled into newer things. Specification of the proposed garbage collector device is given as follows:

(i) Suction power: 800 W

(ii) Waste storage: 0.45–1 kg of plastic

(iii) Shredder capacity: it can crush up to 0.25 mm to 1.5 mm bottle wall thickness

(iv) Weight machine can carry up to 20 kgs

(v) Battery power: 12 v 1.3 A

3. Results and Discussion

The input to the shredder consists of plastic, paper, and chart board materials that can be crushed to small pieces by the metal shredder, for example, paper cups, water bottles, broken chart boards, and plastic cans.

Any one of the trash shown in Figure 6 is first absorbed by a vacuum cleaner guided by a servo motor and it is lifted up to the level of falling into the shredder. The shredder then crushes the trash into pieces and drops it down on the storage box below the surface of the holder board. The controls are all manually monitored to avoid any situation that leads to accidental crushing up of any other materials not specified. The complete process is shown step by step in Figures 7–9. The minimum power to be used in the suction pump is 800 W.

The storage box below the surface of the holder board is placed at an angle such that when the door of the box is opened vertically upwards, the trash slides out of the chamber without any residual deposits.

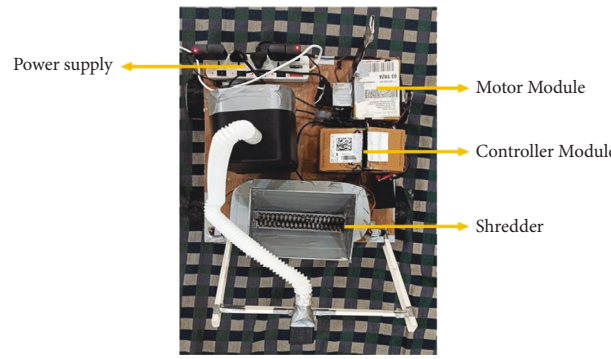

Figure 7: Shredder pickup path.

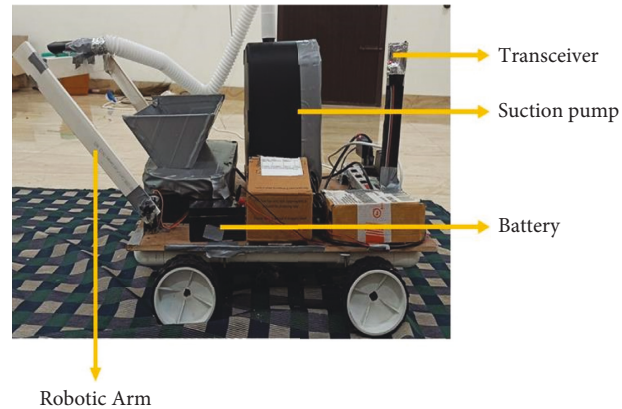

Figure 8: Full view of mobile crusher.

The box also contains an ultrasonic sensor to measure the amount of trash deposited into the storage box. Once the threshold level is reached, the system disposes of the waste into a baggage area. The method of disposal comprises of disposing the trash into a garbage area that arises after the microcontroller is notified of a threshold level of waste in the storage box. Then, it again returns to the left-off position and continues to clean off the remaining disposed wastes. To

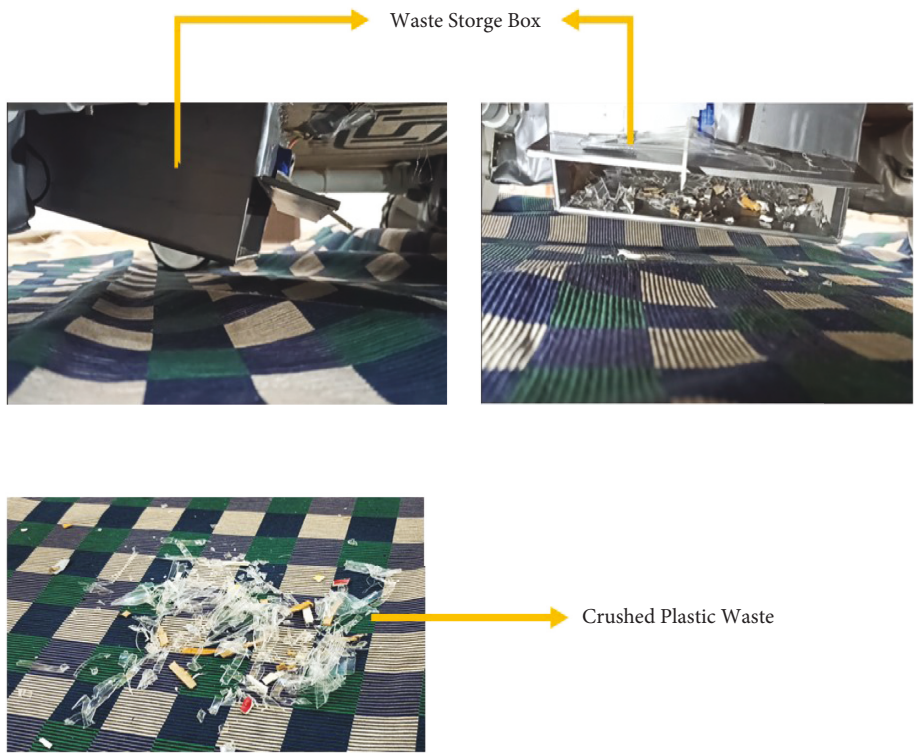

Figure 9: Sample of crushed output.

increase the capacity of the existing garbage collector, the following modifications can be done. (i) Normal Gear motors can be changed to planetary gear motor which will increase the torque so it can carry up to 100 kgs. (ii) Battery capacity needs to be increased from 1.2 A to 7.5 A and lead acid battery is changed to a lithium-ion battery. (iii) Storage capacity can also be increased. (iv) Advanced microcontrollers can be utilized to increase the processing speed.

4. Conclusion

This prototype model for waste collection is the order of the day. Last year only our government banned all plastic materials. However, for the current situation, again large number of plastic covers, masks, and virus protective dresses made the environment worse. So, this prototype is not just a hobby but a real-time useful environment-friendly device that will be utilized for real-time waste collection which will be made automatic with additional features in near future. Real-time application examples of the proposed compact mobile crusher are individual homes, small community areas, and small institutions such as temples, rural, or semiurban areas that are present within out-of-city limits. In order to fetch the waste in the interior places also, automatic control switch is provided, and whenever the machine is in on condition, it will move to the particular place and collect the waste. Hence, the proposed crusher behaves as a robot in cleaning the waste provided we can adjust the capacity according to our purpose. If we utilize the same for domestic purposes, it completely picks up the waste thereby reducing the burden of the manual workers. Initially, a prototype is designed to clean the plastic waste which will be extended to other materials also.

Data Availability

The data used to support the findings of this study are included in the article.

Disclosure

This study was performed as a part of the Mettu University, Mettu, Ethiopia.

Conflicts of Interest

The authors declare that they have no conflicts of Interest.

Acknowledgments

The authors would like to thank the K. Ramakrishnan College of Technology for their excellent support for the submission of their papers.

References

[1] R. Darshan and S. Gururaja, "Design and fabrication of crusher machine for plastic wastes," *International Journal of Mechanical and Production Engineering*, vol. 510 pages, 2017.
[2] 2022, https://greencleanguide.comindia-to-eliminate-single-use-plastic-by-2022.
[3] D. Oliver and A. Prieto, "Plastic Waste Management, a Matter for the Community," *Microbial Biotechnology*, vol. 12, pp. 1–3, 2018.

[4] R. Joshi and S. Ahmed, "Status and challenges of municipal solid waste management in India: a review," *Cogent Environmental Science*, vol. 2, no. 1, Article ID 1139434, 2016.
[5] K. Ragaert, L. Delva, and K. van Geem, "Mechanical and chemical recycling of solid plastic waste," *Waste Management*, vol. 69, pp. 24–58, 2017.
[6] 2019, https://swachhindia.ndtv.com›Plastic Waste.
[7] S. Thiyagesan, R. Shankaran, and V. Kumar, "Smart garbage collector and disposer," *International Journal Of Current Engineering And Scientific Research*, vol. 5, no. issue 2, 2018.
[8] P. Morajkar, V. Bhor, D. Pandya, and A. Deshpande, "Smart garbage management system," *International Journal of Engineering Research and Technology*, vol. 4, no. 3, 2015.
[9] S. Sreejith, R. Ramya, and A. Sanjay kumar, "Smart BIN for waste management system," in *Proceedings of the 5th International Conference on Advanced Computing & Communication Systems (ICACCS)*, Coimbatore, India, March 2019.
[10] H. Saha, S. Auddy, S. Pal et al., "Waste management using internet of things (IOT)," in *Proceedings of the 8th Annual Industrial Automation and Electromechanical Engineering Conference (IEMECON)*, Bangkok, Thailand, August 2017.
[11] T. Anagnostopoulos, A. Zaslavsky, and A. Medvedev, "Robust waste collection exploiting cost efficiency of IOT potentiality in smart cities," in *Proceedings of the 1st IEEE International Conference on Recent Advances in Internet of Things, RIoT*, Seoul Republic of Korea, June 2015.
[12] M. S. U. Maheswari, V. Rohini, G. Surdeep, and M. Varshini, "Smart waste management and predicting BINS with high waste index," *International Journal of Innovative Technology and Exploring Engineering*, vol. 9, no. 7, pp. 482–485, 2020.
[13] T. Vasileios, "Anagnostopoulos and arkady zaslavsky "effective waste collection with shortest path SEMI-STATIC and dynamic routing" 4," *LNCS*, vol. 8638, pp. 95–105, Department of InfocommunicationS Technologies, ITMO University, St. Petersburg, Russia, 2014.
[14] C. Ishwarya, S. Jayashree, and P. Yesodha, "Microtronics technologies," *GSM based garbage and waste collection BINS overflow indicator*, vol. 32 pages, 2017.
[15] K. G. Narendra, C. Swamy, and K. N. Nagadarshini, "Efficient garbage disposal management in metropolitan cities using VANETs," *Journal of Clean Energy Technologies*, vol. 2, no. 3, pp. 258–262, 2014.
[16] I. R. Khan, M. Alam, and A. Razdan, "Smart garbage monitoring system using IoT," *SSRN Electronic Journal*, 2021.
[17] A. Maheshwari, A. Tyagi, and N. Joshi, "To improve efficiency of garbage collection system for smart cities: review paper," in *Proceedings of the International Conference of Advance Research & Innovation (ICARI)*, Punjab, India, March 2020.