Development of an Automatic Control Waste Management System

Jamiu Olasina & Ojo Adaramola
Department of Computer Engineering, Federal Polytechnic Ilaro, Ogun State, Nigeria.
jamiu.olasina@federalpolyilaro.edu.ng; ojo.adaramola@federalpolyilaro.edu.ng

ABSTRACT
Cleanliness and solid waste management are some of the key infrastructures to provide a decent value of life to humankind. But owing to the lack of adequate knowledge of waste management, the waste is being irrationally disposed of everywhere and this is done at will. Some of these irrational methods of disposing of waste include disposing the waste on the roads, playgrounds, campus, and even in the worst scenarios, some students and other institution user dump waste in the lecture rooms without considering the negative effects of this act on their health and the environment at large. To overcome the behavioral attitude of people towards waste management and ensure a sustainable environment, a system that will collect the waste and evaluate the data are significant as a decision sustenance tool to aid local authority or waste management authority to progress and be more efficient in their services. To meaningfully contribute to improving waste management in society, this work was based on the development of an automatic control waste bin system, and this has an Arduino board and c-programming as the bedrock that stands as the control unit for the system, where the motor driver generates a suitable driving signal for the stepper motor, the motion detector sensor senses any object that moves towards the waste bin, and the level sensor that is mounted under the waste bin cover would sense the level of the garbage, and the LCD as a display to help display the processes going on in the system. However, the deployment of this system in a strategic location for waste collection will greatly enhance the health standard and make the environment clean for use.

KEYWORDS: Arduino Board, Motion Detector, Stepper Motor, Waste Bin, Waste Management

1. INTRODUCTION

Many people suffer severely from the effect of irrational waste management especially in the area where waste is being disposed of imperfectly. In some countries, trash is improperly disposed of in rivers and even in streets which have undecorated concerns for people's health, safety, and even the environment (Pardini et al., 2020). However, the concerns system to ensure a clean environment is no longer functional and it generates unhealthy environments for the people and this equally helps the transfer of diseases and sickness. To solve this problem, we developed an efficient management system to effectively manage and control the unsanitary situation. This system offered several advantages over manual approaches previously used which include an increase in efficiency, saves time, improved productivity, and resource utilization reduction (Muhammad et al., 2019). The system required electronic devices to achieve the automatic control process such as The Arduino board which serves as the control unit that allowed several sensors and devices to be automatically and manually controlled and monitored. It consists of features that allow it to spontaneously and independently take actions that are required based on predefined factors (Aravindhu et al., 2017). Everything needed to support a microcontroller is present in the Arduino board by simply using a USB cable to connect it to a computer or using a battery or AC-DC power adapter to get started (Patil et al., 2018). The board has 14 pins (input/output) of which 6 can be used as PMW outputs, 6 analog inputs, and a reset button (Poonam et al., 2017). The motor driver amplifies the low current control signal to generate a high current signal to drive the stepper motor. The integrated IC comprises 16 pins and is used mostly to ensure the required voltage signal level are supplied (Poonam et al., 2017). The level detector sensor HC SR04 has a 2cm-450cm measuring range and 2mm accuracy. It operates within 5V Dc operating voltage, it has less than 2mA static current and can sense at an angle less than 15 degrees (Singh et al., 2017). The ultrasonic sensor analyzes the distance between the objects in the waste bin using acoustic waves (Ranjana, 2019). The motion detector PIR (pyroelectric Infrared) module which is mostly used in a security system has a motion sensor that can be connected to other devices that operates when it senses object motion (Iyapo, et al., 2018). The device can be placed outside to

monitor the area around the waste bin. To view the level of the garbage in the bin, a device called liquid crystal display (LCD) will allow you to know the percentage level. It is a 16*2 module notify the percentage level of rubbish in the bin (Singh et al., 2017).

2. LITERATURE REVIEW

Different works on waste management have been implemented by different researchers using different approaches. In other to appreciate their meaningful contribution to the development of this technology, their work was briefly reviewed in this section.

Designed and developed a smart green environment garbage monitoring system using an ultrasonic sensor for garbage level measurement and ARM microcontroller to control system operation as established by (Mustafa., & Ku, 2017). Four different types of garbage such as plastic, paper, glass, and domestic waste were configured to indicate the status of the system through liquid crystal display (LCD) and Think Speak. The systems were connected to Thing Speak to alert the waste management authority in real-time whenever the bin is filled. The information from the system can further be stored for future use and evaluation. They, however, concluded that the designed system will ensure a greener environment by allowing the garbage to be smartly monitored and controlled via the Internet of Things.

The rapid increase in population has made some country to neglect issues about cleanness as regard garbage management, and this according to (Mahajan et al., 2017). They stated that this idea is not effectively measured. And this has caused unhealthy conditions for the citizens resulting in disease outbreaks and sickness. This unsanitary condition can be monitor and control by deploying an IoT based Smart Waste Management system. They, therefore, deployed a public dustbin implemented with an embedded device for real-time monitoring of the garbage levels in the dustbin. The data obtained as regards the garbage level in the dustbin will serve as a yardstick for the garbage collection vans to route their movement to reduce the cost related to fuel consumption. The data gathered will further help metropolises and government authorities to develop plans as regard smart waste management based on the report generated by the system.

The rapid population growth according to (Susila et al., 2018) has led to polluted and contaminated environments which have adverse effects on the life of people and therefore required necessary steps to ameliorate this unhygienic condition. But using the traditional method of waste bin management is not practicable for the present-day situation because this requires time, effort, and cost. The situation requires a system that will monitor the garbage container thereby sending a message to the waste management authority when the waste bin is filled up. They, therefore, implement a smart waste management system comprised of Arduino board, GSM, sensors, and UNO. They concluded that the designed system will help in preventing unsanitary condition and ensured a healthy environment.

One of the big challenges according to (Nkolika et al., 2019) in most countries today is indiscriminately dumping of refuse all over the cities of which effects result in degradation and pollution of the environment, a disease outbreak in the cities, aquatic destruction, and land wasted. To have a viable ecological improvement for such a country, a proficient waste management system is therefore needed. They however designed a smart waste management system that consists of a power supply unit, the load driver, the sensors, the load, the control unit, the communication module, and the output display. They concluded that proper implementation of this system will enhance and improved the condition of the cities thereby making the cities litter-free and also served as a means to generate revenue.

According to (Zeb et al., 2019), the Internet of Things as an evolving technology provides solutions to manual approaches. It allows a method of developing a smart home, smart cities, smart industries, and smart environment. With the help of the Internet of Things, smart waste management architecture for smart cities with efficient routing techniques to determine the quality of services (QoS) such as end-to-end to overcome delay that may occur during data transmission

using the internet was presented. They however concluded that obtained simulated results outperformed the traditional approaches to waste management.

Although different waste management bins have been implemented by several researchers, but in this particular work, a waste bin prototype was designed to automatically operate when the presence of a human is detected at a particular distance (1meter) which allows it to move forward and open the lid, close it back after the garbage has been dropped, and finally, move back to its original position. The idea was conceived to help users and people with disabilities with ease of usage.

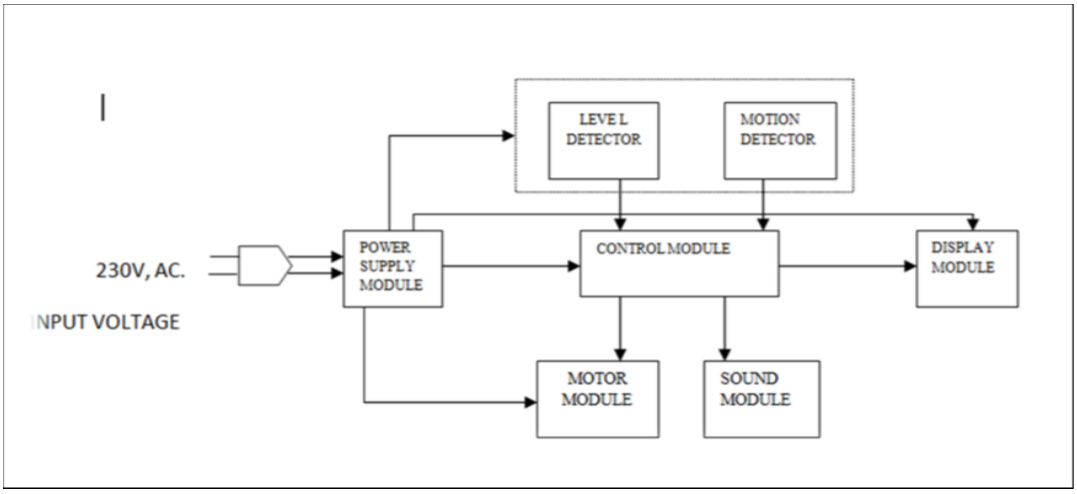

Fig.1: Block Diagram of an Automatic Control Waste Management System

3. METHODOLOGY

The implementation of the system is divided into 1) Hardware module and 2) Software module. The hardware module is divided into the following subsystems: power unit, controller unit, motor unit, sensory unit, and display unit. The software uses Mikro-C for PIC and the system's block diagram is shown in Fig.1. According to Figure 1 above, the control unit will monitor all operations of the system because all other modules were connected to it. The sensory unit gets the analog data, while the control unit process it in digital form, and execute the next action according to the prescribed function of the system. The sound would be generated whenever the bin is filled up. Motor unit is responsible for movement of the entire system. The display unit therefore displays current information of the system.

3.1 Design and Implementation Stages

The overall system was implemented after some of the components have been designed. The following diagrams describe the various sections during the implementation of the Automatic Waste Bin. The two separate sensors perform different tasks, one monitor, if the bin is full or not while the second one detects the presence of a person that wants to use the bin. The capacity check circuitry will activate the LED display as soon as the bin is filled up. The system's design was based on the suggested parameters by the datasheets of the Arduino-Uno, LCD, sound module, motor, and it's motor drivers, ultrasonic sensors, and power section was carefully designed based on the 12V DC motors and 5V DC controller. The power system was regulated, filtered, and regulated to produce, 12V DC and 5V DC respectively.

3.1.1 Simulation of the System

The automatic waste bin management system is simulated as shown in Figure 2, and also, this helps to physically observe the behavior of the system before its final realization.

3.1.2 Bread Boarding and Soldering

The designed components were breadboarded after the simulation had proved successful. The idea is to be sure of the system's workability and so that, if any error occurs, it would be easy to correct. After the breadboarding, the components were then transferred onto the Vero board for permanent soldering according to Figure 3.

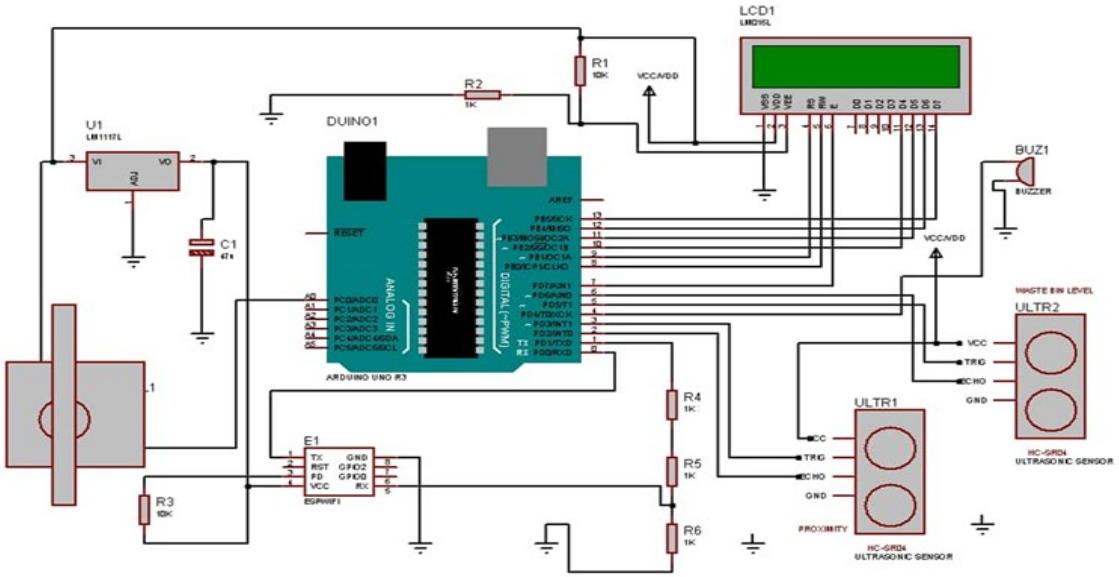

Fig. 2: Simulated Automatic Waste Management System

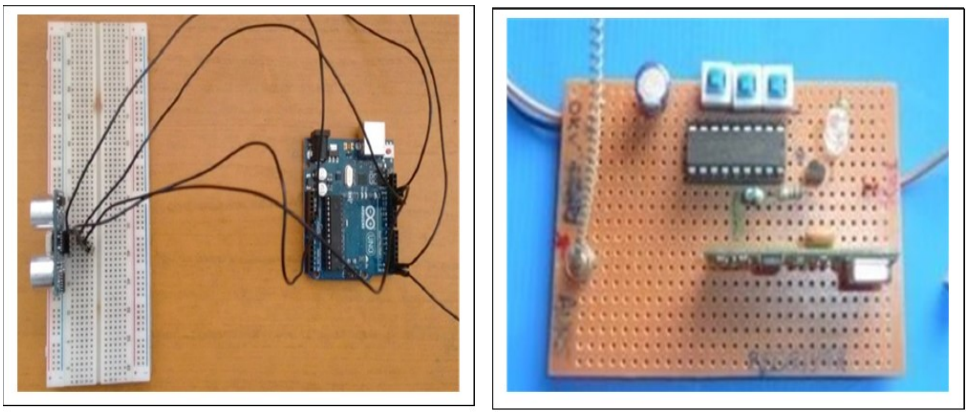

Fig. 3: Diagrams, Showing the Components on Bread Board and Soldering on Vero Board

3.1.3 Packaging

The packaging was done with locally sourced materials, and each stage of the work and up to the final product are shown in Figure 4, and Figure 5. The complete electronic board for the automatic waste management system was housed in the white-colored rectangular solid block of plastic material, and this is mounted to the waste bin, and this forms the control box of the system. Below the control box is the sensor that measures the distance between the system and the person that wants to use the waste bin. The opening and closing actions of the system is controlled by the electric motor. The other sensor attached to the cover of the waste management system helps to monitor the level of refuse in the bin. The whole system has two rollers at the back and the front wheel is attached to the motor system that helps to drive the system in any direction according to the operation mode.

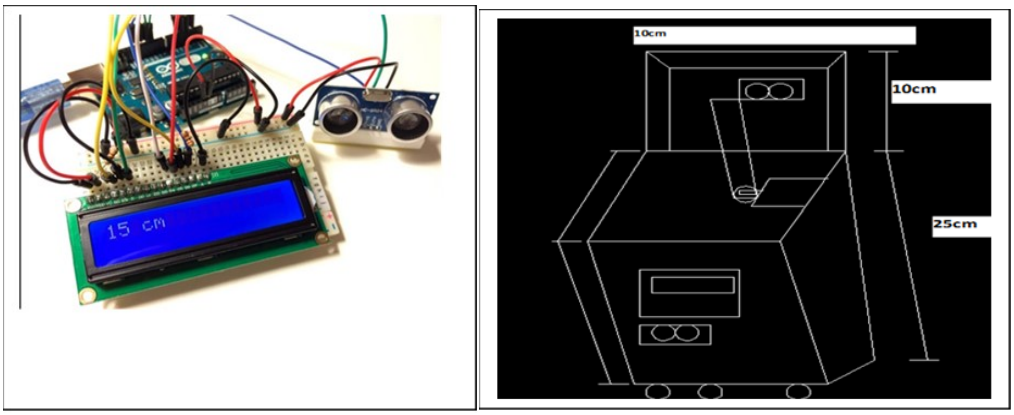

Fig. 4: Detailed Components on Bread Board and Drawing of the Casing

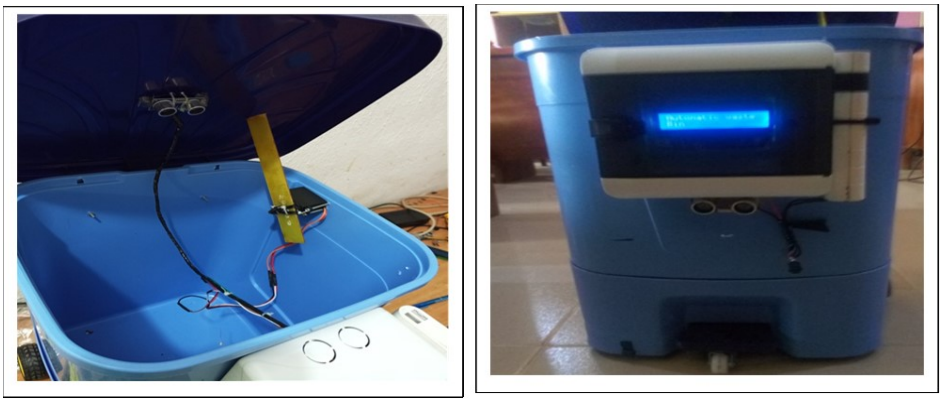

Fig. 5: Packaged Finished Product

4. RESULTS AND DISCUSSIONS

Automatic waste management system works with the aid of two sensors, one to open and close the bin and the other to detect the position of an object and in this case, when it senses a man around, it will move closer to the person so that the person can drop the refuse if there is any and if not, the system will move away from the person to meet somebody else and if it does not see anybody around, it will become inactive to save the battery. Also, the bin automatically opens up and closes up by itself when the sensor detects any motion effect across itself and when the waste bin is full, it will activate an alarm system, to show that, the system is full. Also, a few parameters were calibrated to see the relationship between them and to be able to establish some facts about the behavior of the system. To further illuminate the understanding of these parameters relationship, The data from Table 1 below were analyzed with Microsoft Excel application package and graphs illustrating different actions were equally plotted and in a nutshell, the system works perfectly with a high level of integrity.

According to Fig.6 above, it is evident that as time increases with the weight of the system, the speed is gradually going down, meaning that, when the load continues increasing, there will reach a point, where the speed will reach zero, and at such point, the system will not be able to move at all. That also signifies that it should not be overloaded as that can results in slowing down the system, thereby reducing its efficiency and also, its reliability. The decrease in the speed was traced to the motor torque, and that also, signifies that, when the total weight is equal to the motor torque, the system will remain motionless. Also, when the system is overloaded, the motor will be forcing itself to overwork and when such a scenario remains for so long, it may cause another problem to the motor, and another major implication is that the motor in this difficult state, will be drawing more current and if the system is on battery mode, it quickly drains the battery. The distance chosen was 20 meters.

Table1: Data Acquired During System Operation

S/N	Time (Sec)	Mass (Kg)	Distance (m)	Speed (m/s)
1	10	0.05	20	1.98
2	20	5	20	1.9
3	30	7.5	20	1.78
4	40	10	20	1.5
5	60	12.5	20	1.34
6	80	15	20	1.15
7	100	17.5	20	1.04
8	130	20	20	1.02
9	170	22.5	20	1.01
10	220	25	20	0.95

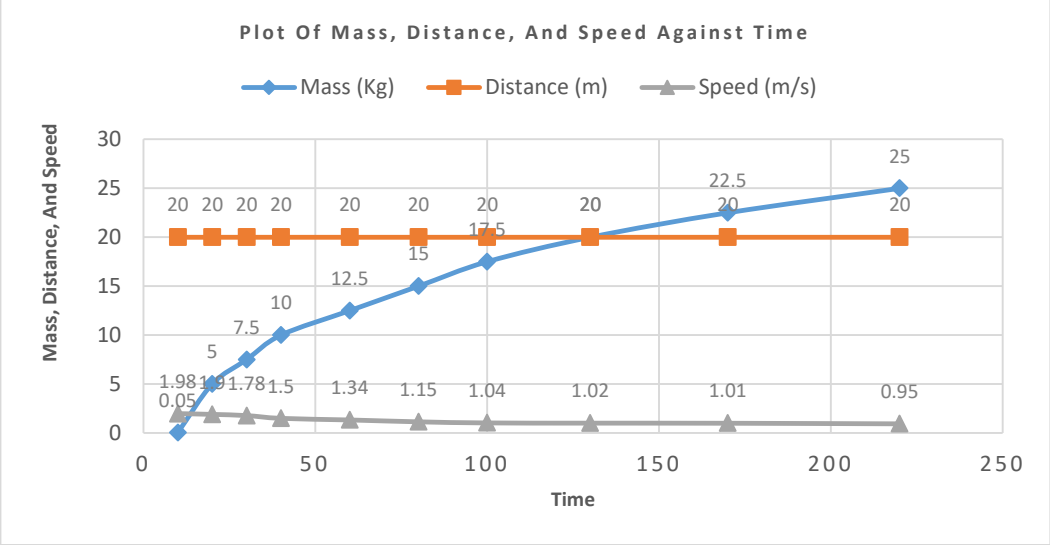

Fig. 6: Plot of Mass, Distance, and Speed against Time

5. CONCLUSION

The designated values for the components according to the datasheet of Arduino Uno, ultrasonic sensors, motors drivers, electric motors, and relay were used to set up the circuit diagram of the waste management system on the proteus simulator, with embedded –C for Arduino and libraries for sensors and motors, the system works tremendously well and thereafter, the simulated system was implemented temporarily on the breadboard, and it also works perfectly well. By these two, evidence, the components were thereafter transferred onto the Vero board, where they were permanently soldered. The entire system was then housed in a container that is mounted to the bin. The system works perfectly well, the door of the bin opens and closes automatically, the entire system with the help of control and electric motors, moves itself to the person and it also moves away from the person. The battery can last for about 12hours and the aim of the implementation was fully achieved. It was studied that the speed of the system depends on the total weight of the system with a load of refuse inside it. The total load should not be more than 25kg.

The following recommendations were suggested:

- The technology should be adopted and use in an environment where there are people with disabilities
- The technology should be deployed in an area that is hazarddeous to human health to ensure proper waste management methos.

REFERENCES

Bhavana Patil, Harsh Amrite, Kailas Gaikwad, Jagdish Dighe, & S. H. (2018). SMART CAR MONITORING SYSTEM USING ARDUINO. *International Research Journal of Engineering and Technology (IRJET) e-ISSN: 05*(03), 3–6.

Kamoru Olarewaju Iyapo, Olukayode Michael Fasunla, Shadrack Alaba Egbuwalo, A. J. A. & O. T. O. (2018). DESIGN AND IMPLEMENTATION OF MOTION DETECTION ALARM AND SECURITY SYSTEM Kamoru. *International Journal of Engineering and Advanced Technology Studies Vol.6, 6*(1), 26–38.

Mahajan, P. S. A., Kokane, A., Shewale, A., & Shinde, M. (2017). *Smart Waste Management System using IoT*. *6495*(4), 93–95.

Muhammad, A., Durrani, F., Rehman, A. U., Farooq, A., Meo, J. A., & Sadiq, M. T. (2019). An Automated Waste Control Management System (AWCMS) by using Arduino. *2019 International Conference on Engineering and Emerging Technologies (ICEET)*, *February*, 1–6. https://doi.org/10.1109/CEET1.2019.8711844

Mustafa, M R F., & Ku, A. K. N. (2017). Smart Bin : Internet-of-Things Garbage Monitoring System. *MATEC Web of Conferences 140, ICEESI.*, *01030*, 1–4. https://doi.org/10.1051/matecconf/201714001030

Nkolika, O., Ibrahim, N., & & Seun, O. K. (2019). DEVELOPMENT OF A SMART, AUTOMATED WASTE. *European Journal of Engineering and Technology*, *7*(2), 46–55.

Pardini, K., Rodrigues, J. J. P. C., Diallo, O., Das, A. K., Albuquerque, V. H. C. De, & Kozlov, S. A. (2020). A Smart Waste Management Solution Geared towards Citizens. *MDPI Journal of Sensors*, *20*(8), 1–15.

Poonam, M., Ms, B., Radke, S., Vrushali, M., Ms, R., & Larokar, N. (2017). *Emergency Alert for Women Safety with Location Tracking using Arduino*. *5*(10), 919–920.

Ranjana, A. B. A. & P. (2019). Design Of A Monitoring System For Waste Management Using IoT. *1st International Conference on Innovations in Information and Communication Technology (ICIICT)*, 1–6. https://doi.org/10.1109/ICIICT1.2019.8741499

S.Aravindhu Ram, N.Siddarth, N.Manjula, K.Rogan, K. S. (2017). REAL-TIME AUTOMATION SYSTEM USING. *International Conference on Innovations in Information Embedded and Communication Systems (ICIIECS) REAL-TIME*, 1–5.

Singh, N., Wagh, P., & Shahare, N. S. (2017). *A Review Paper on Garbage Level Monitoring System for Smart Cities*. *6*(10), 160–165. https://doi.org/10.17148/IJARCCE.2017.61027

Susila, N., Anand, S., Elwin, J., G., R., & Sujatha, T. (2018). Technology Enabled Smart Waste Collection and Management system using IoT. *International Journal of Pure and Applied Mathematics*, *119*(12), 1283–1295.

Zeb, A., Ali, Q., Saleem, M. Q., Awan, K. M., Alowayr, A. S., Uddin, J., Iqbal, S., & Bashir, F. (2019). *A Proposed IoT-Enabled Smart Waste Bin Management System and Efficient Route Selection*. *2019*.