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# VENDOBIN: An IOT-based Plastic Bottle Waste Disposal Vending Machine

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**ABSTRACT:**At the onset of 2010 onwards, environmental protection stands in a precarious position. In the Philippines, about 35,580 tons of garbage is generated everyday. On the average, each person in the country produces about 0.5 kg and 0.3 kg of garbage every day both in the urban and rural areas. This study aims to reduce plastic waste bottles through dispensing usable products (ballpoint pen and bundles of newsprint) in exchange of the disposed plastic bottles. VendoBin is a combination of garbage bin and vending machine. This study aims to develop a habit of proper disposing of plastic bottles through rewards system. VendoBin were developed using Raspberry Pi 3, single-chip computer used in controlling the components. Classification between plastic bottle and non-plastic items were done using the Infrared Sensors. Ultrasonic Sensors were used to determine the status of the VendoBin whether it is full or not. Point systems will be given to every user on every transaction and saved on the text file database. The new or old users is given a unique code needed to redeem usable items. When the VendoBin reaches threshold limit, it will send a text message to the concerned authorities for disposal. VendoBin were able to classify 100% plastic bottles to non-plastic items successfully. The machine also successfully generated the code both to new and old users.

**KEYWORDS**:*Reverse Vending Machine, Internet of Things (IoT), Waste Management, Raspberry Pi, GSM Module*

## 1.0 INTRODUCTION

The escalating amount of plastic bottle wastes has called the attention ofenvironmentalists as it had an impact to the environment specifically a contributing factor in the climate change. These issues raised concerns on how to manage the disposal of such amount of wastes vis-a-vis

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recycling and waste management initiatives. Many efforts were poured out on information drive and campaign for educating the public. Not only that, several laws were also drafted and passed to mitigate its impact to health and the environment.

In the last few decades, garbage management has become serious matter in the country. According to research entitled "Nutrient Enrichment, Sedimentation, Heavy Metals and Plastic Pollution is the Marine Environment and its Implications on Philippine Marine Biodiversity: A Review" unsegregated and improperly dumped garbages and unabated garbage dumping at sea is one of the contributory factor to have been found to have negatively influence marine biodiversity in the country. These issues raised concerns on how to manage the disposal of such amount of wastes vis-a vis recycling and waste management initiatives [1].

In the Philippines, the waste management concern was embodied through the Memorandum Circular 39-A in January 1988 and its amendments and through the Republic Act 9003 or also known as "Ecological Solid Waste Management Act of 2000". This act makes provision for the efficient solid waste management. [2]

Despite the efforts of the government in increasing public awareness towards solid waste management, sustaining this is a challenge. Fundamental shift in mindset and behaviours should start within ourselves to solve this problem. From the beginning of school education, mass awareness of household waste management has a great impact on waste disposal practices [3].

Another study emphasized that the knowledge of the student towards solid waste management has a significant contribution the attitude of the students towards solid waste management [4].

There is no greater way to do this paradigm shifts through rewards and incentives. Incentives offers desirable behaviours towards recycling and proper garbage disposal. In changing these mindsets, there is a need to educate individuals. There is no better institution in educating individuals than the school.

Vending machines has been around in the early 1880s. This first modern coin-operated vending machines dispensed postcards [5]. In these modern times, reverse vending machines are used for different purposes, one of which was for storing used containers in exchange for coins [6].

Although reverse vending machine already exists in other country such as Germany, Russia and among others [7], these machines are relatively new in the Philippines. The proponents of this study created a plastic waste disposal vending machine implemented in school that will dispense usable products as rewards.

In order to create the vending machine, several researches on different designs of garbage bins for proper waste management has been reviewed.

Study conducted by Tur et. al develop a reverse vending machine that makes use of conventional camera in recognizing containers. The identification method, which recognizes object using neural networks with Raspberry Pi 3 [7].

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The study conducted by IOT based smart garbage alert system used Arduino UNO as controlling boards. Garbage level was monitored using ultrasonic sensor interfaced with Arduino Uno. Arduino sends alert to the municipal web server ones garbage was filled [8].

Another study makes use of Raspberry pi as controlling boards. Pi was interfaced to GSM modem, ultrasonic sensor and weight sensor. Pi was used to calculate the threshold height to check if the bin was filled. GSM modem will send message to administrator [9].

Another study conducted, develop a reverse vending machine with stored value system using radio frequency identification (RFID). The machine accepts plastic bottles and credits these as points, which in turn, can be used to buy products [10].

Study conducted by P. Nehete et al, develop a smart dustbin in which GSM board send message by detecting the level of garbage with the help of infrared rays (IR) in the dustbin [11].

In designing a reverse vending machine, there are several rewards systems and incentives from different machines. Presented below are different forms of rewards and incentives.

Vending machines developed in India utilized useful things as token of appreciation for those who will throw their garbage on the reverse vending machine [12].

In the study conducted by Tur et. al, in their study they summarize existing reverse vending machines with their incentives from different countries. LoetecElektronischeFertigungssysteme GmbH in Germany used cash, coupons, mobile phone account, “RICH”, Ltd. In Russia used coupons, utility bills and mobile phone account, PANDA-MAT in Ukraine used cash and coupons, Zhengzhou Honest Machinery CO., Ltd used cash, coupons, mobile phone account used coupons and mobile phone account and INCOM TOMRA Recycling Technology (Beijiing) co., Ltd used coupons [7]. Another type of vending machine used school supplies as rewards [13].

L. Lolikar et al worked on a smart bin using GSM (Global System for Mobile communications) modem and ultrasonic sensor interface with Arduino Uno board as platform is prototyped [14]. Another way of sending this data is using WI-FI module sent with mobile web browser [15]. Another study makes used of Narrow Band Internet of things (NB-IoT) communication module to transmit information [16].

In the above mentioned study, the proponents created a VendoBin that will used IR sensors for identifying plastic bottles, Ultrasonic sensor for checking the bin if its filled and text-based redeeming of points.

## 2.0 METHODOLOGY

For this study, researchers used raspberry pi 3 as microcontroller and python programming language for code implementation.

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**2.1 Hardware Development**

A matrix membrane keypad or the number pad is used initially by the user who would like to dispose plastic bottle in the machine to start the system process. If the user has an existing account in the machine, the number pad can be used to access their account and retrieve their existing data. The number pad will also be used in choosing the desired item during item redemption. Every time the user will dispose plastic bottle in the machine, an IR sensor together with an ultrasonic sensor will validate the object placed by the user first before the bin will open to drop the plastic bottle inside the machine. Two 360-degree servo motor will open the bin after the object is verified to be a plastic bottle. An IR sensor inside the machine will then be able to sense the dropped bottle and count the number of bottles dropped by the user. A 360-degree servo motor will be used in the dispense mechanism of the machine. The rotating function of the servo motor will be used to push the item chose by the user to dispense it. The LCD will reflect every operation done by the user with the machine—from displaying the user's points to generating unique random codes for new user accounts.

Two ultrasonic sensors will be used to monitor the status of the bin whether it is almost full or not. A GSM module will be used to send SMS notification to one of the researchers if the bin is almost full. Two push buttons will then be used for raspberry pi's safety—one button will be used as a shutdown button to properly shutdown the raspberry pi and one button will be used as a reboot button in case the machine needs to be rebooted due to possible errors. Figure 1 shows the overall hardware set-up and interrelationship of every components to each other.

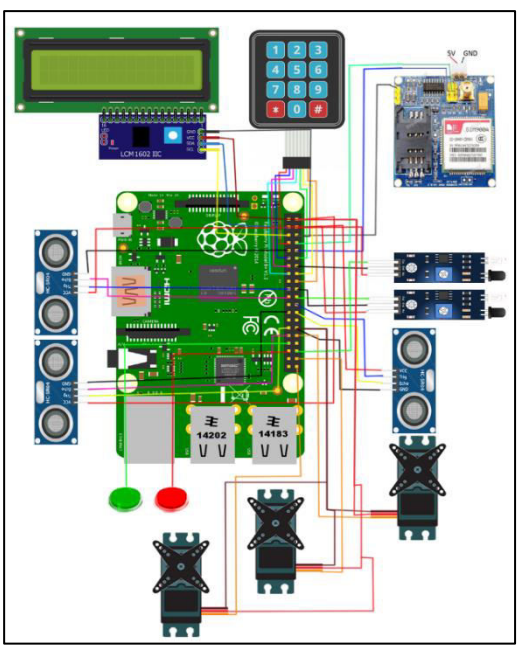


Figure1:Hardware Components

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**2.2 System Flow**

Figure 2 shows the system overflow. It started by checking the status of the bin. If the bin is full, a message will be sent to the concern authorities. If the bin is not full, the user will place the plastic bottle at drop mechanism. The IR integrated in the drop mechanism will classify whether the object placed is plastic or not. If you are a new user, the machine will create a code. If one is an existing user, it will be saved in your account. After that, the user given an option to redeem now or later. If the user choose to redeem now, points stored will be checked. If the user has sufficient points, it can redeem usable items. Points will be deducted after dispensing the item.

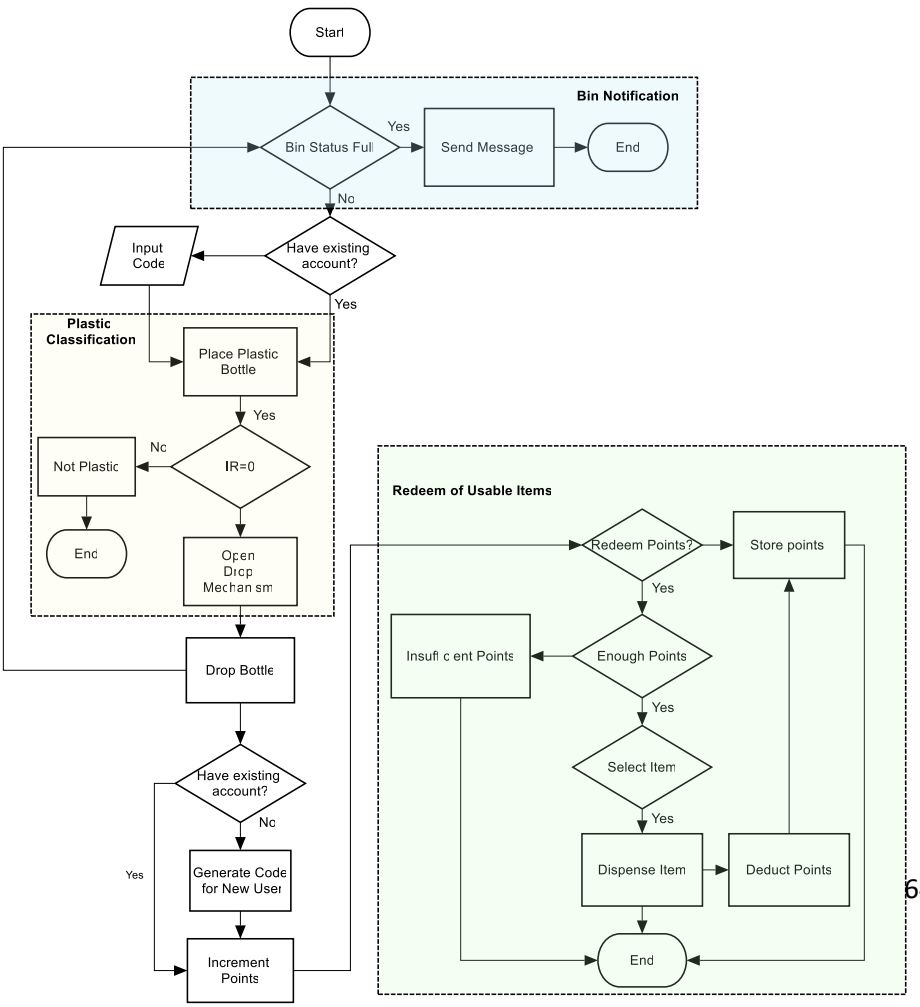

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Figure2:System Overflow

**2.3 Threshold Values**

In detecting plastic bottle, threshold values where used.The value 0 on the IR sensor implies that no object is detected since the plastic bottle has a glass like clarity characteristic. The value on the plastic bottle verification table implies that if it is 1 then it successfully detected the object as a plastic bottle, if 0 then it is not a plastic bottle. Table 1 shows parameters in classifying plastic bottles.

In notifying the admin if the bin was almost full, two ultrasonic sensors were used to determine if the bin is almost full. Twenty centimeters (20 cm) was the set distance away from the sensor. If ultrasonic 1 detects an object which is the plastic bottle and the ultrasonic 2 does not detect any object then the bin was still not full and also vice versa. If both ultrasonic detects an object then the status of the bin was full. Table 2 shows the values of two ultrasonic sensors with corresponding bin status.

Table 1: Plastic Bottle Classification Threshold Values

| **IR Sensor** | **Verification** |
|---|---|
| 0 | Plastic Bottle |
| 1 | Not Plastic Bottle |

Table 2: Bin status Threshold values

| **Ultrasonic Sensor 1** | **Ultrasonic Sensor 2** | **Bin Status** |
|---|---|---|
| 0 | 0 | Not Full |
| 0 | 1 | Not Full |
| 1 | 0 | Not Full |
| 1 | 1 | Full |

**2.3 Prototype Design**

Figure 3 shows the prototype design of the VendoBin. The right side is where the plastic bottles were stored. The other side was where the ballpoint pen or roll of newsprint. Figure 4 shows the top view of the VendoBin. In designing the VendoBin, the researchers considered the material will not rust immediately, since some of the plastic may contain water.

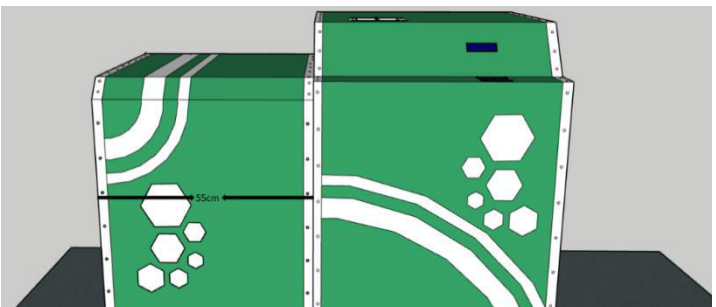

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Figure3: VendoBin Prototype

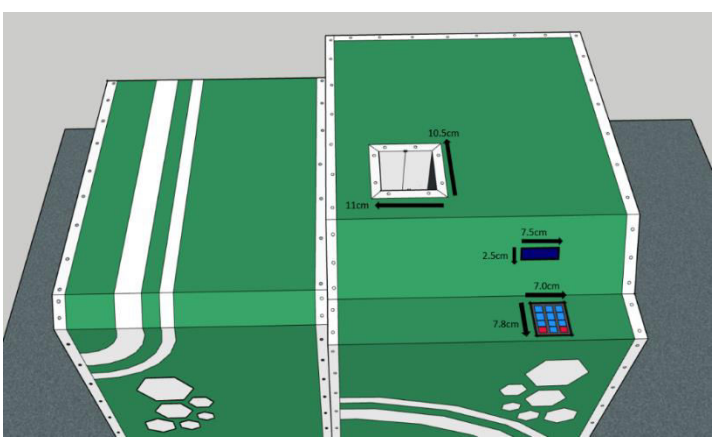


Figure4: Top View of the VendoBin

**2.4 Drop Mechanism and Drop Counter**

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For drop mechanism, two "sliders" (e.g., a knob or lever that is moved horizontally or vertically to control a variable) together with two continuous rotating servo motor is used for the drop mechanism of the machine. After the object placed, it was classified as a plastic bottle, the two servo motor will rotate to a direction that will open the drop mechanism to drop the plastic bottle inside the bin. Every time the user will drop plastic, IR sensor below will serve as a counter and increment points. Figure 5 shows the drop mechanism (left) and drop counter (right).

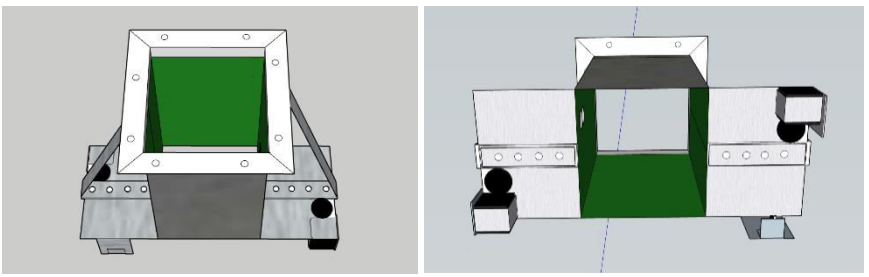

Figure4: Drop Mechanism and Counter

## 3.0 RESULTS AND DISCUSSION

In classifying the plastic bottles, several testing was conducted. This include positive inputs (plastic bottles) and negative inputs (paper cups). For positive inputs, there were samples of different brands of plastic bottles, which where tested. The test was conducted to ensure the VendoBin can identify different types of plastic bottles. Table 3 shows the result in testing different samples. VendoBin was able to identify plastic bottles accurately. Table 4 shows other inputs such as paper cups and juice containers.

Table 3: Plastic Bottles as Input

| Types of Bottle | Number of Trials | Number of Successful Trials | Percentage Accuracy |
|---|---|---|---|
| Sample 1 | 20 | 20 | 100% |
| Sample 2 | 20 | 20 | 100% |
| Sample 3 | 20 | 20 | 100% |
| Sample 4 | 20 | 20 | 100% |
| Sample 5 | 20 | 20 | 100% |
| Sample 6 | 20 | 20 | 100% |
| Sample 7 | 20 | 20 | 100% |
| Sample 8 | 20 | 20 | 100% |

Table 4: Negative Inputs

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| Types of Bottle | Number of Trials | Number of Successful Trials | Percentage Accuracy |
|---|---|---|---|
| Sample 1 | 20 | 20 | 100% |
| Sample 2 | 20 | 20 | 100% |

In generating code for old and new users, researchers conducted 53 trials. The VendoBin was able to generate code for both users consistently. Table 5 shows the number of trials and total generated code for both users.

In the case that the bin is full, a message is sent to the concern authorities. The researcher conducted 50 trials. Out of 50 trials, there were 43 successful trials. Failed trials are due to errors encountered in the ultrasonic sensor detection. Table 6 shows the SMS notification result with 86% accuracy.

In redeeming items, 50 trials were conducted for both dispensing of Ballpoint pen and roll of newsprint. In dispensing ballpoint pen, the VendoBin is 82%, the failed trials on the pen is due to displacement of pen inside the dispenser. On the other hand, newsprint dispense 100% accurately.

Table 5: Generation of Code

| User | Number of Trials | Number of Generated Code | Percentage Accuracy |
|---|---|---|---|
| Old | 53 | 53 | 100% |
| New | 53 | 53 | 100% |

Table 6: SMS Notification

| Number of Trials | Number of Successful Trials | Percentage Accuracy |
|---|---|---|
| 50 | 43 | 86% |

Table 7: Dispensing of Usable Products (Ballpoint pen and Roll of Newsprint)

| Product | Number of | Number of | Percentage Accuracy |
|---|---|---|---|

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| | Trials | Successful Trials | |
|---|---|---|---|
| Ballpoint Pen | 50 | 41 | 82% |
| Roll of Newsprint | 50 | 50 | 100% |

## 4.0 CONCLUSION

In the dispensing of two usable products namely ballpoint pen and newsprint, there were 50 trials conducted and only 41 trials were successful which is equivalent to 82% because of the improper placing of the ballpoint pen inside the dispenser. In dispensing the bundle of newsprint, all 50 trials were 100% successful.

All plastic bottles and non-plastic bottles were successfully identified by the VendoBin. The generation of code for both new and old users were successfully generated and saved in the database.

There were 43 out of 50 messages were successfully sent to the authorized authorities informing the status of the VendoBin. Failure is due to ultrasonic sensor not detecting the garbage.

The researchers were able to design and develop a vending machine and a recycle bin for plastic bottles, that can also dispense two usable products namely ballpoint pen andbundles of newsprint successfully. The future scope of this study is to improve the dispensing system and additional features to improve the VendoBin.

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**REFERENCES**

[1] Abreo, N. A. S., Macusi, E. D., Cuenca, G. C., Ranara, C. T. B., Andam, M. B., Cardona, L. C., &Arabejo, G. F. P., "Nutrient enrichment, sedimentation, heavy metals and plastic pollution in the marine environment and its implications on Philippine marine biodiversity: A Review". *IAMURE International Journal of Ecology and Conservation*, 15(1), 111-167, 2015.

[2] Castillo, A. L., &Otoma, S.,"Status of Solid Waste Management in the Philippines. In Proceedings of the Annual Conference of Japan Society of Material Cycles and Waste Management" *24th Annual Conference of Japan Society of Material Cycles and Waste Management* (p. 677). Japan Society of Material Cycles and Waste Management, 2013.

ISSN- 2394-5125 VOL 07, ISSUE 15, 2020

[3] Licy, C. D., Vivek, R., Saritha, K., Anies, T. K., &Josphina, C. T.,"Awareness, attitude and practice of school students towards household waste management". *Journal of Environment*, 2(6), 147-150.

[4] Adeoye, P. A., Sadeeq, M. A., Musa, J. J., & Adebayo, S. E., "Solid waste management in Minna, North Central Nigeria: present practices and future challenges". *Solid Waste Management: Policy and Planning for a Sustainable Society*, 103, 2013.

[5] Segrave, K, Vending machines: an American social history. McFarland, 2015.

[6] Dewoolfson, B. H., & Dawson, D. (1988). U.S. Patent No. 4,784,251. Washington, DC: U.S. Patent and Trademark Office.

[7] Tur, A. I., Kokoulin, A. N., Yuzhakov, A. A., Polygalov, S. V., Troegubov, A. S., &Korotaev, V. N.,"Beverage Container Collecting Machine Project". *IOP Conference Series: Earth and Environmental Science* (Vol. 317, No. 1, p. 012006). IOP Publishing, 2019.

[8] Kumar, N. S., Vuayalakshmi, B., Prarthana, R. J., & Shankar, A.,"IOT based smart garbage alert system using Arduino UNO". *2016 IEEE Region 10 Conference(TENCON)* (pp. 1028-1034). IEEE, 2016.

[9] Chaudhari, M. S., Patil, B., &Raut, V., "IoT based Waste Collection Management System for Smart Cities: An Overview".*2019 3rd International Conference on Computing Methodologies and Communication(ICCMC)* (pp. 802-805). IEEE, 2019.

[10] Dumpayan, W. G. P., De Mesa, M. L. M., Yucor, N. D. F., Gabion, E. T., Reynoso, J. D., &Geslani, G. R. M., "Two-way powered microcontroller-based plastic bottles 'drop-and-tap'reverse vending machine with stored value system using radio frequency identification (RFID) scanner technology". *2017IEEE 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management(HNICEM)* (pp. 1-8). IEEE, 2017.

[11] Nehete, P., Jangam, D., Barne, N., Bhoite, P., &Jadhav, S.,"Garbage Management using Internet of Things". *2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA)* (pp. 1454-1458). IEEE, 2018.

[12] Balubai, M., VamsikiranSure, V., Reddy, V. M., Gowtham, S. R., &Subbiah, R. A New Approach in Manufacturing of Reverse Vending Machine. *International Journal of Advanced Engineering, Management and Science*, 3(7).

[13] Lambiquet, M. V., Lecong, L. E., Cervantes, S. L., Reyes, K. M., Agustin, C. B. &Robillos Jr., H. E.. (2012). School Supply Vending Machine. PULSAR, 1(1). Retrieved from http://ejournals.ph/form/cite.php?id=7151

[14] Luis, M., Lotlikar, D., Fernandes, C., & Cardoso, M. (2017, January 3). Smart Bin using GSM Modem [Scholarly project]. In International Journal for Scientific Research & Development. Retrieved from http://ijsrd.com/Article.php?manuscript=IJSRDV4I120432Smart bin using GSM Module

[15] Navghane, S. S., Killedar, M. S., &Rohokale, V. M., "IoT based smart garbage and waste collection bin". *International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)*, 5(5), 1576-1578.

[16] Pan, P., Lai, J., Chen, G., Li, J., Zhou, M., & Ren, H., "An Intelligent Garbage Bin Based on NB-IOT Research Mode". In 2018 *IEEE International Conference of Safety Produce Informatization (IICSPI)* (pp. 113-117). IEEE, 2018.