Electronic Bio-hazard Waste Disposal Device

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ABSTRACT

The study developed an electronic waste bin for bio-hazard wastes. It is a common knowledge that medical wastes that are not properly disposed can bring huge damage to the environment as well as to the health of the people. The waste bin was designed to segregate different medical waste such as those expired pharmaceutical products, sharp tools and solid infectious disposable waste as well as to discern its acceptability in terms of its functionality and environment safety. The design set up of the study includes the principle of sensor technology such as liquid leak detector and proximity sensor incorporated to prevent contamination in opening the bin. An infrared proximity collision sensor used for automatic opening and closing of the bin to minimize the chance of infection through contact on the bin and provides automatic sealing of each bag to prevent bacteria spread-out. The device takes up to 3 seconds to open the bin automatically and 13.5 inches maximum level capacity in order to seal the garbage bag inside it, it also indicates what type of waste should be thrown in each bin whether biodegradable, non-biodegradable and pathological waste. Based on the findings it has been concluded that the study satisfied its objectives based on the result gathered where the respondents agreed in terms of functionality and environmental safety to be highly effective.

Introduction

Industrial as well as household wastes generated daily grow in volume and accumulate higher toxicity. There are some toxins that have high potential for disease transmission. This Biohazard waste or biomedical waste causes a major world problem that is damaging to all life forms through an increasing risk of contamination.

Infectious laboratory waste found in hospitals, health care facilities, medical research institutions and industrial facilities

are wastes that contain microorganisms capable of causing infection in a healthy susceptible host. Medical, diagnostics, research, and industrial processes may be the source of blood and body fluids from an individual who harbors an infectious agent maybe a threat to public health and environment.

"We Find Ways" as a well-known memorable advertisement line of Banco de Oro (BDO) became also the aim of the proponents to solve this kind of socio environmental problem to make a study entitled Electronic Bio-hazard Waste Disposal Device that enable to open the lid automatically when garbage is being thrown in, and store it in a much more secure garbage bin.

At its maximum capacity, the bin seals and an LCD screen will display the time when this bag was set There will also be leak detection sensors at the bottom of the waste bin and a warning message will appear on the LCD screen.

Purpose of the Research

In general, this study fits into an overall strategic plan to establish a "Stand-Alone" innovative waste bin. Likewise; it also aimed to attain the following:

1. To determine the design of an innovative waste bin for bio-hazards wastes that will segregate the different medical waste such as those with expired pharmaceutical products, sharp tools like syringe and solid infectious waste disposable waste like cottons and bandages.

2. To determine the level of performance of the innovative waste bin for bio-hazards wastes as to:

    a. Time to open the bin;
    b. Volume capacity to seal the garbage bag; and
    c. Types of Biohazard waste

3. To determine the level of acceptability of the innovative waste for bio-hazard wastes bin in terms of its functionality and environment safety.

Literature Review

Every proponent must needs to take into the account that a research is a continuous course of action that builds preceding knowledge. Through the support of collected data from books, magazines, manuals, pamphlets, unpublished thesis and the internet, these will provide the background of information that supposedly gives a clearer background to a concise overview of this research. In relation to the research study and related literatures conducted by the different professionals and scientist, similarities and comparisons were made by the proponents that can be useful in drawing inferences and constructing the research framework of the study.

Biohazard waste has often been defined differently by researchers, countries, international NGOs and other global institutions.

According to Saugat,B. (August 2013), biological hazards, also known as biohazards, refer to biological substances that pose a threat to the health of living organisms, primarily that of humans. It includes medical waste or samples of a microorganism, virus or toxin (from a biological source) that can affect human health (a biological contamination).

Many synonyms to biohazard waste exist, and are currently used interchangeably in different scientific journals all over the world. To name a few are bio medical waste, hospital waste and clinical waste.

As defined in Hazard Awareness Management Manual (HAMM, 2016), biohazard waste also called infectious waste

or biomedical waste is any waste containing infectious materials or potentially infectious substances such as blood of special concern are sharp wastes such as needles, blades, glass pipettes and other wastes that can cause injury during handling.

Additionally, Abor and Bouwer (2008) focus their definition of clinical waste to include all types of wastes produced by health facilities such as hospitals, medical centers and dispensaries.

According to Jones, (2010) "Keep our planet clean by using types of waste bins", it is likely that there will always be some people who litter in towns and in the country, despite fines and knowledge of the environmental consequences. You cannot change the way other people care for our planet but you can at least do your part to keep it clean. Do not litter and do not dispose of your waste in way that will harm people or animals. Always use the proper method for disposing of waste such as a waste bin.

Waste bin comes in different sizes, color and type of materials used depending on the users so they can be easily identified and makes work easier.

Waste Bin, specifically which contains contaminated clinical waste is the primary concern and subject of the present study. Disposal Operation was used in almost every day; it is implemented by the local government to ensure the safety of the community from hazardous waste that may affect the health of the people.

As stated by Marinkovic et.al (2008), the space for temporal storage according to should be out of reach of patients and staff, properly marked and accessible to authorized personnel.

Disposal options change as technology and environmental concerns change. That is why it is necessary to innovate.

According to Schumpeter (2008), innovation is distinguished from invention by the fact that innovation is usually applied successfully in practice.

The economic tradition regarding technological change is concerned with innovation as technological invention used in the industrial process as stated by Godin (2010a), innovation in the first tradition was concerned with process innovation; the second tradition specifically gave greater place in analyses to product innovation.

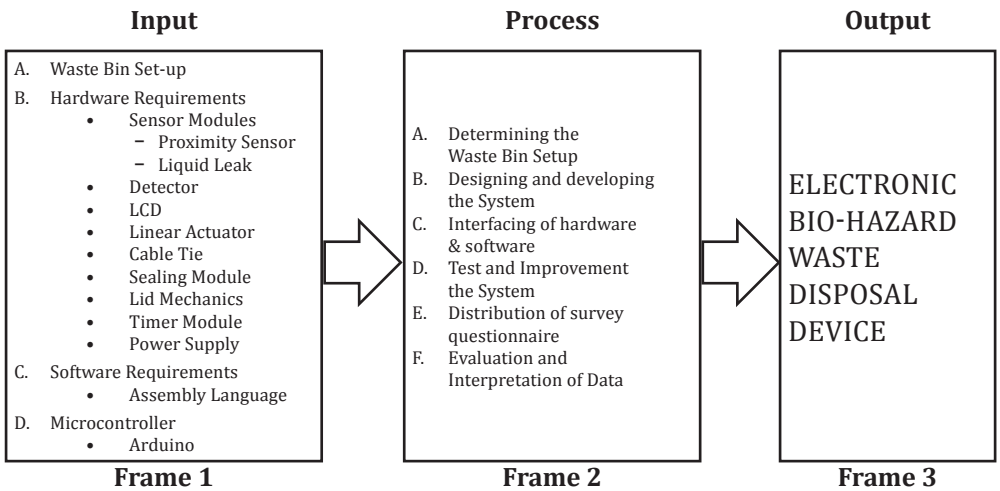

Figure 1: Input, Process and Output of the Study

Methodology

Figure 1 depicts the research paradigm of the study.

Frame 1 – The input or the information needed consists of Waste Bin set-up, hardware requirements and software requirements.

Frame 2- The process which pertains to the procedure deals with the theories and practice on designing, interfacing, testing and revisions found during test period and the evaluation and interpretation of data through survey questionnaire.

Frame 3- The final output is the Electronic Bio-hazard Waste Disposal Device.

Employing ideas in developmental research designs guided the researchers to the project study entitled Electronic Bio-hazard Waste Disposal Device for the reason that the proponents determined what may occur later in this study. It enables the determination of the outcome or output from its process of analysis, identification, collection, observation and conclusion. The design included thorough analysis, developmental researches, and consultations.

The survey questionnaires were distributed and rated by 15 students of the College of Nursing and four Medical and Dental staff of Laguna State Polytechnic University Sta. Cruz Campus using random sampling techniques. The analysis of data used descriptive statistics such as weighted mean and standard deviation.

The Innovative Waste Bin Set Up is divided into two parts the hardware and software requirements. The hardware components such as sensor modules, microcontroller module, lid module, sealing module: display module and power module:

A sensor module, also known as Detector Module measures physical quantity and converts them into signals which can be read by the microcontroller unit (MCU) module. Here three types of sensors are re-implemented, namely Infrared Proximity Sensor and Water Leak Detector. The proximity/infrared sensor was installed around the lid to determine when to open the lid and used to determine whether the current bag is full. Liquid detection sensor was installed at the bottom of the waste bin to detect any liquid leakage.

Sealing module was used to seal the trash bag.

The outputs of these sensors were implemented as inputs to the MCU module. The MCU module receives analog data and converts them to digital data. The sensors are powered by connecting to the Power Module.

The lid module open or closes the lid of the waste bin according to the signal given by the microcontroller module.

Timer Module keeps track of the current bag of trash until it is sealed. The timer provides information into the controller module.

A LED display is a flat panel display that indicates the date for current bag of trash. Also, the LED panel indicates if there is any liquid present in the bin. The microcontroller receives signals from the sensor modules and sends signals to lid mechanics, dc motor gear and LED display.

The Power Module converts AC power supply to DC voltages and powers each module with respect to their requirements.

Supplies and Materials

The components and the materials that the proponents used in the design project undergone a number of considerations which primarily includes the affordability

of the design project, the availability in the local market of the components used, and the cost of the project

Table 1

Supplies and Materials

List of Supplies and Materials

Quantity	Materials
3 pcs.	DC Motor with Gear Motor
3 pcs.	Trash Can
3pcs.	Cable Tie
3 pcs	Trash Bag
1 pc.	Power Supply AC or DC Adapter
3 pcs.	IR/ Proximity Sensor
3 pcs.	Proximity Sensor
2 pc.	Liquid detection Sensor
1 pc.	PCB
50 cm	Resistive Wires
3 pcs.	Linear Actuator
1 pc.	LCD Screen Display

Table 1 shows the supplies and materials used in the construction of the prototype together with their quantity and specifications.

Construction Procedures

For the purpose of obtaining the desired output for the whole circuitry, step by step procedures have to be implemented prior construction of the whole prototype and to spend the allotted time in construction effectively.

Data gathering and analysis was done first where preliminary research, conceptualization and tests were considered such as testing of the effective orientation of the sensors, lay-out and design including determining the appropriate components and schematic diagram needed for the LCD circuit and sensors circuits were established.

For the assembly of materials, canvassing of all the tools and materials needed were considered.

Program Development was the next procedure where developing, testing and debugging of program and interfacing of all hardware and software was done.

Visual testing and possible revisions were made before the finishing stage, where final checking and testing of the entire device and possible modification were done.

The Evaluation was done through distribution of survey questionnaire and interpretation of such data obtained.

Flow Chart

The system flow chart of the program used for the project study Electronic Bio-Hazard Waste Disposal Device.

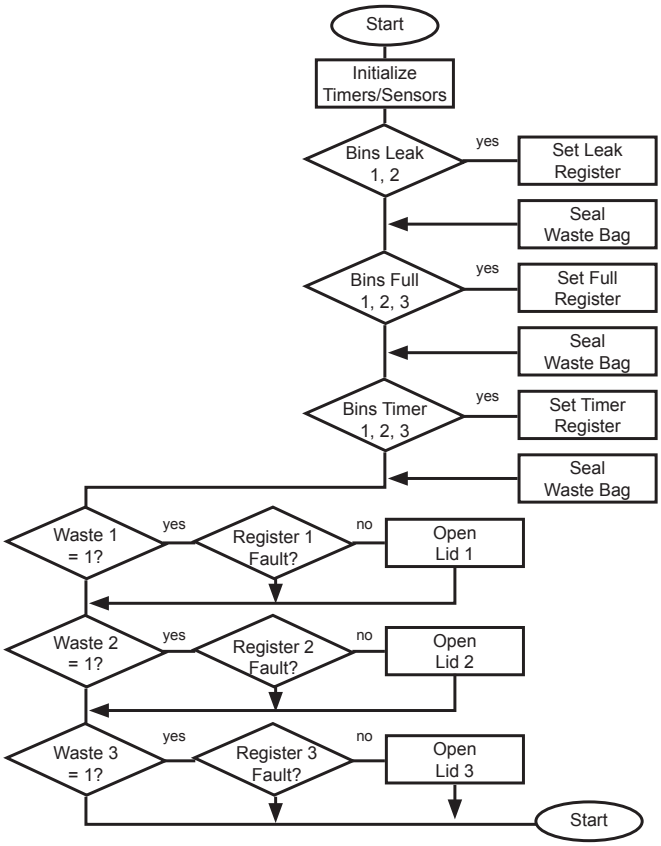

Figure 2: System Flow Chart

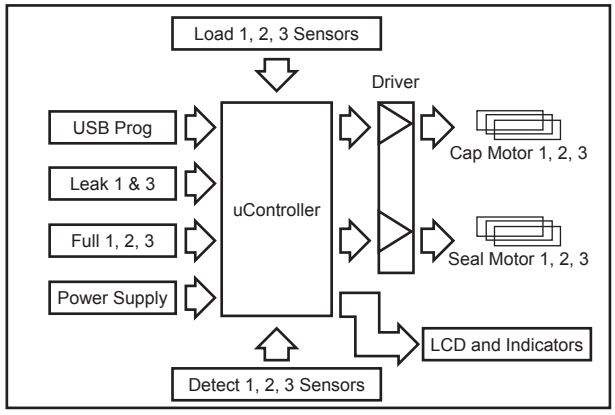

Figure 3: Block Diagram.

Figure 2 show that the process initializes the timer, liquid leak detector and the proximity sensor for the level of garbage. The process would start when the lid sensor sense the presence of garbage. Sealing module will operate whenever the bag has leak and the bag is full. If the bin reached the set time, timer register will be triggered and bag would be sealed.

Block Diagram

The microcontroller functions as the heart of the system. Several sensors serve as input to the microcontroller. The LCD screen serves as display to indicate input that has been processed, and the power supply provides power to the system.

Schematic Diagram

The diagram below shows the system development of the Electronic Bio-Hazard Waste Disposal Device.

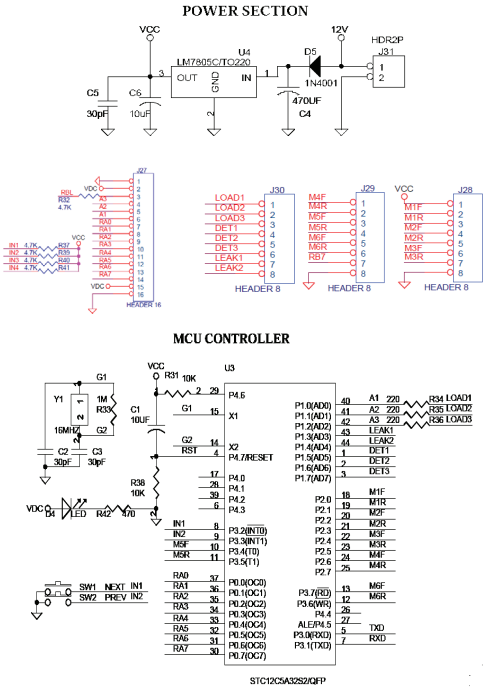

Figure 4. Power Section and Microcontrollers.

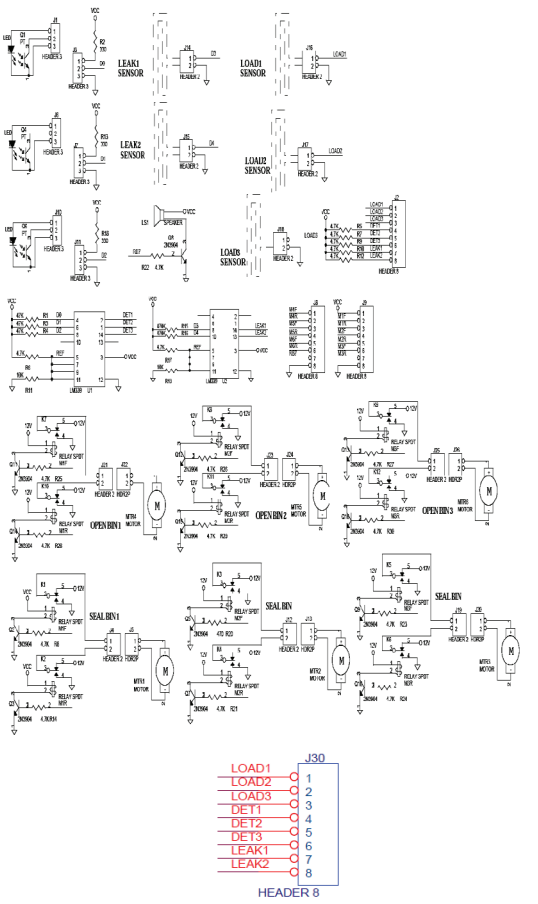

Figure 5. Sensors and Motors.

ACTIVITY	Number of Weeks														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Conceptualizing the design of the Project.	Nov. 18-24, 2013														
2. Preparation, canvassing and purchasing of supplies, materials, tools and equipment.		Nov. 25-Dec. 2, 2013													
3. Construction of circuit diagrams and assembly of the device.				Dec. 9-23, 2013											
4. Program Development and Interfacing the microcontroller							Dec. 30, 2013 - Jan. 13, 2014								
4. Try-outs and Revisions										Jan. 20 - Feb. 3, 2014					
5. Finalization and Completion of Project													Feb. 10-16, 2014		
6. Evaluation														Feb. 17-Feb. 24, 2014	

Figure 6. Gantt Chart.

Figures 4 & 5 shows schematic diagram of the power section, microcontroller, sensors and motors components used in construction and development of the Electronic Bio-Hazard Waste Disposal Device.

Construction Time Frame

The time duration for the completion of the prototype design was carefully planned as shown in Figure 6, showing the tasks and activities corresponding the number of weeks in the accomplishment of the prototype. As shown in the Gantt

chart, the study encompasses 15 weeks of working time to be able to attain the purpose of the study.

Results and Discussion

The data presented were analyzed and interpreted by the proponents that determined the level of performance and acceptability of the Electronic Bio-Hazard Waste Disposal Device in terms of functionality and environment safety of the bin. The questionnaire checklist were distributed and rated by the students of College of Nursing and Medical & Dental Clinic Staff of Laguna State Polytechnic University, Sta. Cruz Campus.

Table 3

Level of Performance in Terms of Time to Open the Bin

Trial	Time to open the bin in seconds		
	Pathological	Non-Biodegradable	Biodegradable
1	3.5	2	2.5
2	3.4	3	3
3	3.2	2.5	2
4	3	3	2.5
5	3.2	2.6	3
6	3	2.5	3.5
7	3.5	3	2.5
8	3.6	2.5	3
9	3	3	3.5
10	3	3.5	2
11	2.6	3.6	3
12	2.4	3.5	3.5
13	3.5	3.3	2
14	3.5	3.5	2
15	3.6	3	3.5
Average	3.1867	2.7667	2.9667
Theoretical Value	3	3	3
Standard Deviation	0.3583	0.5936	0.4701
Degree Freedom	14	14	14
T- value	2.02	-1.52	-0.27
P-value	0.632	0.1502	0.7876

Table 3 showed the level of performance as to the time to open the bin (average rate =3.1867, 2.7667 and 2.9667, SD= 0.3583, 0.5936 and 0.4701 for pathological, non-biodegradable and biodegradable bin respectively) with 3 seconds set as theoretical value and degree freedom of 14 for the bins.

The P-Value of 0.632, 0.1502 and 0.7876 that is greater than 0.05 and was interpreted as highly effective due to consistency of the output.

Table 4

Level of Performance in Terms of Level Capacity to Seal the Garbage Bag

Trial	Level capacity to seal the garbage bag (inches)		
	Pathological	Non-Biode-gradable	Biodegradable
1	13.4”	13.9”	13”
2	13.5”	13.7”	13.6”
3	13.7”	13.3”	13.7”
4	13.5”	13.2”	13.8”
5	13.8”	13.3”	13.5”
6	13.5”	13.5”	13”
7	13.4”	13.6”	13.4”
8	13”	13.5”	13.2”
9	13.5”	13.6”	13.3”
10	13.5”	13.7”	13.6”
11	13.7”	13.6”	13.5”
12	13.5”	13.4”	13.1”
13	13.6”	13”	13”
14	13.4”	13.4”	13.2”
15	13”	13”	13.6”
Average	13.4667	13.4733	13.3667
Theoretical Value	13.5	13.5	13.5
Standard Deviation	0.2225	0.2251	0.2717
Degree Freedom	14	14	14
T- value	-0.58	-0.46	-1.905
P-value	0.5711	0.6534	0.0781

Table 5

Level of Acceptability in terms of Functionality

Criteria	Automatic Operation of Biohazard Disposal Operation			Manual Operation of Ordinary waste bin		
Functionality	**Mean**	**Standard Deviation**	**Remarks**	**Mean**	**Standard Deviation**	**Remarks**
The device gives convenience to the users.	4.467	0.5164	Agree	3.267	0.4577	Uncertain
The device gives an output that satisfies the users	4.267	0.6113	Agree	3.2	0.7746	Uncertain
The device can prevent contamination	4.4	0.7368	Agree	2.333	0.9759	Disagree
Weighted mean	**4.378**	**0.622**	**Agree**	**2.933**	**0.736**	**Uncertain**

Table 4 showed the level of performance in terms of level capacity to seal the garbage bag (average rate = 13.4667, 13.4733 and 13.3667, SD= .2225, .2251 and .2717 for pathological, non-biodegradable and for the biodegradable bin respectively) 13.5 inches was the set theoretical value of the bins with degree freedom of 14 for the Pathological, Non-biodegradable and biodegradable bins.

The P-Value of 0.5711, 0.6534 and 0.0781 that is greater than 0.05 and was interpreted as highly effective due to consistency of the output.

Table 5 showed the level of functionality of the prototype as determined by the respondents. It showed the criteria that the device gives convenience to the users (M= 4.467, SD= .5164) it also gives an output that satisfies the users M= 4.267, SD= .6113), Likewise, it also indicates that the device can prevent contamination M= of 4.4, SD= .622). The total functionality of the device (M= 4.378, SD= .622) which was greater than the functionality of ordinary waste bin.

Table 6

Level of Acceptability in terms of Environment Safety

Criteria	Automatic Operation of Biohazard Disposal Operation			Manual Operation of Ordinary waste bin		
Environment safety	**Mean**	**Standard Deviation**	**Remarks**	**Mean**	**Standard Deviation**	**Remarks**
The prototype can prevent contamination	4.067	0.5936	Agree	3.4	0.6325	Uncertain
The device provide a more effective way of segregating hospital waste	4.467	0.6399	Agree	3.2	0.8619	Uncertain
The device can contribute proper waste management.	4.467	0.6399	Agree	2.8	0.6761	Uncertain
Weighted mean	**4.334**	**0.6245**	**Agree**	**3.133**	**0.7235**	**Uncertain**

Table 6 showed that the acceptability of the Biohazard Disposal Operation in terms of preventing contamination (M= 4.067, SD= .5936). The device provide a more effective way of segregating hospital waste (M= 4.467, SD= .6399) and when it comes to contributing in proper waste management (M= 4.467, SD= .6245) with the average greater than the ordinary waste bin.

The table 7 revealed the summary of the tabulation of the results. In the terms of the prototype functionality (M= 4.378, SD= .622) marked as acceptable. In terms of Environment safety, (M= 4.334, SD= .6245) and marked as acceptable.

Table 7

Composite Table of Biohazard Disposal Operation: An Innovative Waste Bin

Criteria	Automatic Operation of Biohazard Disposal Operation			Manual Operation of Ordinary waste bin		
	Mean	Standard Deviation	Remarks	Mean	Standard Deviation	Remarks
Functionality	4.378	0.622	Agree	2.933	0.736	Uncertain
Environment safety	4.334	0.6245	Agree	3.133	0.7235	Uncertain
Average	**4.356**	**0.6234**	**Agree**	**3.033**	**0.7486**	**Uncertain**

Conclusion and Recommendations

In the design set up of the Electronic Bio-Hazard Waste Disposal Device, sensor technology was incorporated within the microcontroller programming that uses proximity sensors to open the bin and to detect level capacity of the bin to seal the garbage bag automatically to prevent contamination and segregate the different pharmaceutical product and infectious waste that can be harmful.

The researchers found out that the materials used in the construction of the project for the enhancement of the features of the Electronic Bio-Hazard Waste Disposal Device modified the function of an ordinary medical waste and takes up to 3 seconds to open the bin automatically and 13.5 inches maximum level capacity in order to seal the garbage bag inside the bin it also indicates what types of waste should be thrown in each bin. Thus, the working consumption of the device are minimized by automatic monitoring of the status of the bin whether the garbage bag is full or has a leakage using the program that uses sensor technology.

The device in terms of itsfunctionality and environment safety achieved an average weighted mean of 4.356 and standard deviation of 0.623. The prototype satisfied the objective of the study based on the results gathered and verbally interpreted to be highly acceptable. Thus, it has been found that the device is more appropriate in segregating different medical waste such as those with expired pharmaceutical products and other solid infectious waste.

Based on the findings and conclusion, the following recommendations are forwarded: First; the Electronic Bio-Hazard Waste Disposal Device will be more reliable if the range and sensitivity specifications of the detector sensor will be enhanced. Photoelectric sensors that use light sensitivity in detecting all kind of object maybe utilized.

Second; enhancing the physical appearance by using larger bin that will suit the need of clinics and hospitals is recommended and securing the circuitry inside the bin to avoid unnecessary damage will be of great help. And lastly; it is recommended that the next developer will use a more advance program to improve time consumption in opening the bin and enhanced its functionality and new designs for environmental safety.

■ ■ ■

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