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Solar Powered Automated Waste Restraining Device for Sewages

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Abstract *– In the community, waste is the reason why small-scale sewages or canals are clogging. It is also one of the reasons why floods and long-term floods occur. The study aims to mitigate these specific problems. The research study strived to develop a device specifically for restraining waste floating on a small-scale sewage or canal. Clogged sewage is a blockage of the drainage system that causes the water not to drain, resulting in frequent back-ups such as floods. Blockages are often caused by debris like plastic, dried leaves, pet bottles, etc. The researchers came up with a solution that can help collect substances from clogged sewage to avoid future setbacks. The study proposed a device named "Solar Powered Automated Waste Restraining Device for Sewages." This equipment will prevent the sewages from clogging by restraining and collecting debris on a free-flowing canal using an ultrasonic sensor. This device will automatically send notifications using the GSM module to authorized personnel to repeat the process until the sewage system is clogged-free. To strengthen the effectiveness of the device, the researchers tested the equipment for at least three days to see if it could efficiently lessen the cause of sewage blockages. Keywords — Small-scale Sewage, Waste Restraining Device, Drainage System, GSM Module, Ultrasonic Sensor.*

Keywords *– Drainage system, GSM Module, Small scale sewage, Waste Restraining Device, Ultrasonic Sensor*

INTRODUCTION

The Philippines has been prone to waste being everywhere whether it is on the water or on the streets. According to J. Lamond, et al. (2012), poor waste management can contribute to the impact of urban flooding by blocking drainage, increasing debris and harboring disease vectors. Waste has been one of the major reasons why floods occur in the Philippines. According to S. Subia, et al. (2019), heavy and prolonged rainfall, clogged rivers, canals, creeks and streams, lack of preventive infrastructure and facilities and poor implementation of waste management systems were the possible leading causes of flooding. Waterways are being clogged by waste because of poor waste management and lack of intervention resulting in floods.

Assessing the collected data by the researchers with 5 local Barangays, all 5 locations have the same problem with small-scale sewages. The researchers came up with a machine concept that restrains waste in canals or small- scale sewages to avoid clogging, which can mitigate and prevent future setbacks. The machine is powered by solar energy. First, the device needs to be placed in a canal or small-scale sewage that has free-flowing water. The device will be placed at Juliana Barangay Hall, City of San Fernando, Pampanga. After being placed, a button needs to be pressed in order for the system to initialize, and the restraining container will automatically go under the water and restrain every waste flowing inside the container. The ultrasonic sensor will detect if the container is full. Upon detecting if the container is full, the device will start to pull the container above until it reaches the top, whereas it will notify the nearest household and the barangay to collect the waste. Finally, after the waste is collected, there is a button that needs to be pressed in order for the device to start doing its work again.

OBJECTIVES OF THE STUDY

The objective of the study is to mitigate the possible accidents that the barangay staff may

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experience during cleaning the canals, such as exposure to harmful chemicals, stepping on sharp materials, and etc. Another objective is to replace the traditional cleaning equipment such as shovels, rakes and electric fan cover used by the barangay staff in cleaning the sewages. Lastly, to lessen and prevent the obstruction of any waste that may cause clogging in canals and small-scale sewages.

The device will only be considered for canals that have free-flowing water. It will only accommodate waste that is free-flowing in the direction of the water. It will not accommodate waste if the restraining container is full, as it is above the water and needs to be collected. One human intervention with the device is when, after someone collects the waste, a button is needed to be pressed so that the restraining container will go down under the water to collect again. Canals or small-scale sewage with stagnant water are not covered in this study.

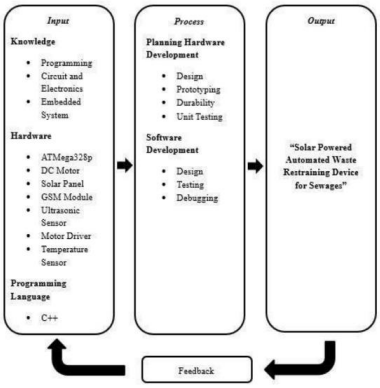

Fig. 1 Conceptual Framework

In the figure above, it shows all the skills, knowledge and components needed to produce in the said project. In the input part under knowledge, you need to know about programming, circuit and electronics, and embedded systems. In hardware/features it includes ATMega328p, DC Motor, Solar Panel, GSM Module, Ultrasonic Sensor, Temperature Sensor and Motor Driver. The Programming Language we used is Arduino Language that is based on C++. Another part of the conceptual framework is process. In planning our hardware development, we need to design, prototype, durability test and unit testing. While in software development we also need to design, to test and debug. The Project Design entitled "Solar Powered Automated Waste Restraining Device for Sewages" is produced.

MATERIALS AND METHODS

The research entitled "Solar Powered Automated Waste Restraining Device for Sewages" is an objective perspective type of study as it aims to solve various problems in small- scale sewages or canals such as clogging, garbage, and other factors. In our country, problems in canals have been worse ever since. Mostly, people dump their garbage on sewages, canals and creeks and that results in clogging. The study's target respondents are barangays/communities in San Fernando Pampanga who are experiencing problems in small-scale sewages or canals, illegal garbage dumping sites, and cleaning methods. The instrument that the study will be using is a survey questionnaire and interview through face to face.

As the researchers collect data on the respondents, they will also obtain consent, asking for permission to gather data and use that data in the research study. A total of 20 respondents from the residents of Barangay Juliana. The researchers also requested nine professionals to evaluate the software quality and hardware components of the device. They also include their profiles to strengthen their claims and show that their professionals are qualified to evaluate the system.

In building the Hardware, the modules that were used are Ultrasonic Sensor, Motor Driver, Real Time Clock Module, ATMega328p, GSM Sim800L EVB module. The researchers checked if the modules are working with each other by printing these modules on a serial monitor result, whereas the researchers also noticed that the GSM Sim800L EVB module is not responding properly and figured out that the module needs sufficient power in order for the module to work intendedly. Another problem that the researchers experienced is the fitting of PCB measurement on an enclosure.

The researchers tested their device in Barangay Juliana for five days. On their first day, they fit the device to see if the measurements were accurate. They did not operate the machine on the first try to make way for polishing the software code and hardware components. On the following day, when they started to operate the device, they noticed that the braces were struggling to support the lead screw because of the narrow space beneath the canal. The researchers troubleshooted what the problem was. They tried changing the braces to thin aluminum material rather than their old braces. A day later, they tried to operate

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the device, and it went smoothly. They continued to test their device up until the last day of testing.

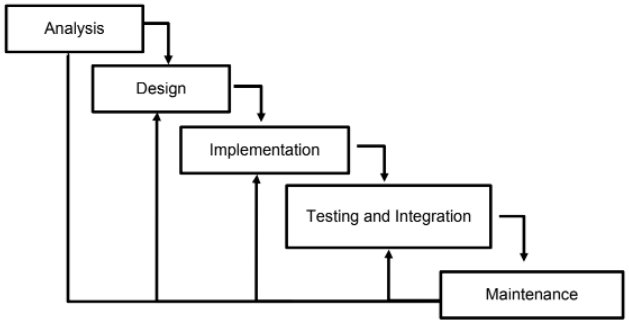

Fig. 2 Iterative Waterfall Method

The Iterative Waterfall Method was utilized in constructing the system. In applying the method, the proponents were required to analyze the problem, whereas its requirements are gathering data, conducting interviews, and research. The proponents conducted a pre-survey in 5 barangays specifically in San Fernando, Pampanga to gather information on what types of problems they were currently facing. The researchers were able to gather information from the barangay officials and crusaders and were able to identify what these barangays have in common in terms of problems, which were mostly in small-scale sewage or canals. In the development of the system, additional research on information through the internet was able to fulfill the requirements.

The completion of the code will proceed with the testing of the system while it is being monitored by the researchers to check its effectiveness, performance, and sequence. It then underwent debugging to update the code for some issues, fix bugs and errors.

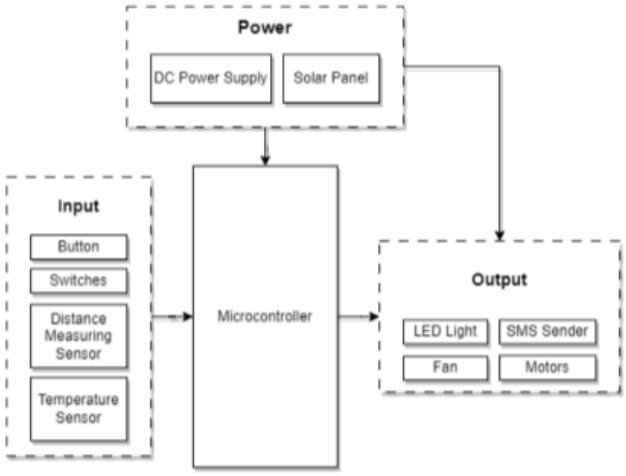

Fig. 3 Block Diagram

In figure 3, it shows that the device will have 4 main blocks. The middle block is the microcontroller that will be the brain of the device. The middle block is surrounded by the input, output, and power block. The input block consists of the buttons, switches, temperature sensor and the distance measuring sensor. The output block consists of an LED used for signaling, SMS sender, fan and motors. Lastly, the power block consists of a and a solar panel.

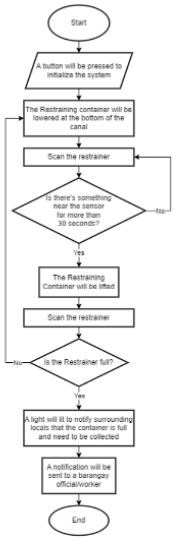

Fig. 3.1 System/Application Flowchart

Figure 3.1 explains the System/Application Flowchart. First, the machine is in default state whereas the container is still above. A button needs to be pressed to initialize the system, automatically bringing the restraining container to the bottom of the canal. Ultrasonic sensor will sense if there is something near the sensor for 30 seconds and then the device will automatically pull the container upward, whereas if not, the container will remain under. It will then scan the container again to confirm that there is something in the container, not just water that has risen up. While the container is full and ready to be collected, the installed LEDs will be lit to notify the surrounding locals, as well as the GSM module sending notification to a barangay official or worker.

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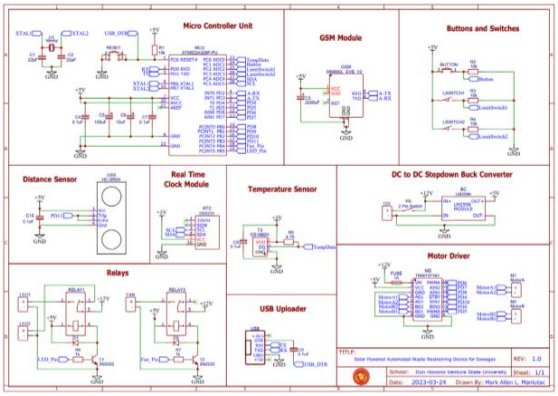

Fig. 4 Schematic Diagram

The figure 4 shows the schematic diagram of the system. The schematic diagram of a microcontroller unit (MCU) is the central component in a system that includes a GSM module, buttons and switches, a distance sensor, a real-time clock module, a temperature sensor, a DC-to- DC step down buck converter, relays, a USB uploader, and a motor driver. The MCU acts as the brain of the system, controlling the various components and ensuring they work together seamlessly.

Fig. 5 Solar Powered Automated Waste Restraining Device

All of the software and hardware components combined result in the creation of Solar Powered Automated Waste Restraining Device. The device can collect waste on a free-flowing small-scale sewage or canal as the restrainer goes down by pushing the button. The span time of collecting waste depends on how fast and how many wastes are getting inside the restrainer. Basically, the span time of collecting waste is tentative.

Table 1: Testing of Deployment

Day	State	Observation
1	Collecting	N/A
2	Collecting	N/A
3	Notified In Need of Collection	Little to no trash was collected

Based on the deployment data the researchers collected, on the third day of waste collection, the device notified the researchers and collected little to no trash. The researchers checked the sensor to see if any possible obstacle was the reason for it to be activated, and it turns out that it was not the waste that activated the sensor. The proponents noticed that the flow and the water level had changed from what they used to be. They concluded that maybe the cause of the problem was the water level.

Table 2: Sewage Water Depth Change

Day	Sewage Water Depth
1	14 cm
2	15 cm
3	12 cm
4	18 cm
5	17 cm

The researchers monitored the water level of the canal for five (5) consecutive days and proved that their conclusions were correct. The change in water level can affect the functionality of the device to collect garbage from the flow of sewage water.

```
bool checkIfRestrainerCanLowerFurther(unsigned int distance)
{...
}
```

```
if (waterLevelLowCounter >= 15)
{
    waterLevelLowCounter = 0;
    return Low_Water_Level;
}
```

Fig. 6 Code for Changing Water Level

This part of the code states that when the device is currently collecting waste and detects that the water level of the canal suddenly decreases, it will automatically be lowered to the right distance from the new water level.

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```
switch (procedure)
{
case Check_False_Alarm:
{
    unsigned int checkDistance = sonar.convert_cm(sonar.ping_median(20, 100));
    if (!checkIfUltrasonicDistanceNormal(checkDistance))
    {
        messageContent = Ultrasonic_Sensor_Error;
        changeProcedureToAndSave(Notify_Components_Malfunctioned);
    }
    else if (checkDistance < raisedRestrainerFullDistance)
    {
        changeProcedureToAndSave(Notify_for_Collection);
        isRestrainerFull = true;
    }
    else
    {
        changeStateToAndSave(Lowering);
    }
    break;
}
```

Fig. 7 Code that Corresponds to False Alarm Due to Water Level

Figure 7 shows the solution the researchers came up with whenever the device was activated due to the water level rising up the surface, as it will recheck the restrainer if there is an object that activates it. If no object is found, the restrainer will lower back to collect again at a new distance because of the water level.

Table 9: Final Deployment

Day	State	Observation
1	Collecting	N/A
2	Collecting	N/A
3	Collecting	N/A
4	Notified and surfaced	Gunk, small leaves, cigarette, big plastic liquid containers
5	Collecting	N/A

In application and correction of the system's code, the device now successfully performs every function without errors. The researchers deployed the device for the second time for testing as well as for waste collection data. They achieved the desired result of collecting waste without problems, as well as filling the restrainer with gunk, small leaves, cigarette boxes, and plastic containers, which lasted for 4 days after being full.

Fig. 8 Collected Garbage on Final Deployment

Table 10: Device Power Consumption Table

Device State	Consumption	Duration
Fully Raised	~45 mA	Continuous
Fully Raised (Fan On)	~0.31 A	1-2 minutes
Lifting	~0.7 A	< 1 minute
Lowering	~0.7 A	< 1 minute
Collecting	~55 mA	Continuous
Collecting (Fan On)	~0.31 A	1-2 minutes

Determining the accumulated data from the respondents for accuracy, the researchers conducted five series of tests, with each test having five attempts.

Table 11: Frequency Table

Data (Successful Attempts)	Mean (x)
3	4
4	
4	
4	
5	

$$\bar{x} = \frac{\sum fx}{N}$$

Where: x = mean
fx = frequency
N = number of attempts

The statistical treatment of data of the proposed study supports the respondents' data. The data refers to how many series of attempts the researchers successfully did, whereas the n refers to the number of series, and x refers to the mean.

Twenty (20) respondents who are residents and barangay officials of Juliana, San Fernando, accomplished the evaluation survey of the study Solar Powered Automated Waste Restraining Device for Sewage. The researchers utilized descriptive survey questionnaires with three specific criteria on reliability, sustainability, and efficiency of the device on how it can restrain waste on free-flowing canals, as well as if the device did what it was programmed to do. This supports the researchers' gathered data from the respondents.

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In assessing the study, the average weighted mean was determined using Descriptive Rating:

Table 12: Rating Scale

Descriptive Rating	Rating Scale
Highly Acceptable	4.51 – 5.0
Very Acceptable	3.51 – 4.50
Acceptable	2.51 – 3.50
Moderately Acceptable	1.51 - 2.50
Not Acceptable	1.00 – 1.50

To get the overall assessment on the reliability, accuracy, and efficiency of the study, the following conversion was used for descriptive rating:

Table 13: Descriptive Rating for Respondents

Weighted Mean	Descriptive Rating		
4.51 – 5.0	Highly Reliable	Highly Efficient	Highly Sustainable
3.51 – 4.50	Very Reliable	Very Efficient	Very Sustainable
2.51 – 3.50	Reliable	Efficient	Sustainable
1.51 – 2.50	Moderate Reliable	Moderate Efficient	Moderate Sustainable
1.00 – 1.50	Not Reliable	Not Efficient	Not Sustainable

Further strengthening the outcome of the evaluation, the researchers conducted a survey questionnaire with three professionals who have degrees and licenses in Electronics and Computer Engineering. The researchers used an evaluation form that was provided by the International Organization for Standardization (ISO), as well as the International Electrotechnical Commission (IEC) 25010, wherein the professionals are able to evaluate the quality of the device and its software. Whereas getting the overall rating uses the following conversion for each category of the provided evaluation form ISO/IEC 25010:

Table 14: Rating Scale for Professionals

Descriptive Rating	Rating Scale
Strongly Agree	4.51 – 5.00
Agree	3.51 – 4.50
Neutral	2.51 – 3.50
Disagree	1.51 – 2.50
Strongly Disagree	1.00 – 1.50

RESULTS AND DISCUSSION

In this section, it shows the examination of the study on how the Solar Powered Automated Waste Restraining Device effectively does its job in collecting garbage from small-scale sewages. This chapter includes the frequency table which is computed by using the mean formula and responses of the participants.

Table 15: Assessment on the Reliability of Solar Powered Automated Waste Restraining Device for Sewages

Assessment on the Study Reliability		
Statements	Solar Powered Automated Waste Restraining Device for Sewages	
	Rating Scale	Descriptive Rating
The device was easy to use	4.75	Highly Reliable
The restrainer's Ultrasonic Sensor was able to detect if the cage was full.	4.85	Highly Reliable
The device restrainer was able to move up and down without problem.	4.8	Highly Reliable
Average Weighted Mean	**4.8**	**Highly Reliable**

Table 15 shows the results of the respondents on the reliability of the device. The total average weighted mean is 4.8 which is equivalent to HIGHLY RELIABLE.

Table 16: Assessment on the Efficiency of Solar Powered Automated Waste Restraining Device for Sewages

Assessment on the Study Efficiency		
Statements	Solar Powered Automated Waste Restraining Device for Sewages	
	Rating Scale	Descriptive Rating
The device was able to perform its task in an ample amount of time.	4.7	Highly Efficient
Average Weighted Mean	**4.7**	**Highly Efficient**

Table 16 shows the results of the respondents on the efficiency of the device. The total average weighted mean is 4.7 which is equivalent to HIGHLY EFFICIENT.

Table 17: Assessment on the Sustainability of Solar Powered Automated Waste Restraining Device for Sewages

Assessment on the Study Sustainability		
Statements	Solar Powered Automated Waste Restraining Device for Sewages	
	Rating Scale	Descriptive Rating
The device was able to restrain waste in flowing canals.	5	Highly Sustainable
Average Weighted Mean	**5**	**Highly Sustainable**

Table 17 shows the results of the respondents on the sustainability of the device. The total average weighted mean is 5 which is equivalent to HIGHLY SUSTAINABLE.

Table 18: Assessment of Solar Powered Automated Waste Restraining Device for Sewages based on ISO 25010

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Aspect	Average Rating Scale	Average Descriptive Rating
Functional Stability	4.3	Agree
Performance Efficiency	4.07	Agree
Compatibility	4.39	Agree
Usability	4.31	Agree
Reliability	4.11	Agree
Security	4.04	Agree
Portability	4.33	Agree
Maintainability	4.22	Agree
Overall Average	**4.22**	**Agree**

Table 18 shows the evaluation of the professional respondents on the overall feature of the device.

The **Functional Stability** of the system passed all the requirements on certain conditions when the device was under use. The average mean is 4.3 which results that the professional respondents AGREE to the functional stability of the system.

The **Performance Efficiency** of the system was able to represent its performance relative to the number of resources used under fixed conditions. The determined average mean is 4.07 which results that the professional respondents AGREE to the performance efficiency of the system.

The **Compatibility** of the system while able to perform its functions while sharing the same hardware and software environment. The determined average mean is 4.39 which results that the professional respondents AGREE to the compatibility of the system

The **Usability** of the system which was its capability of being used by the specified users to achieve certain goals with effectiveness, efficiency and satisfaction in a specified context of use. The determined average mean is 4.31 which results that the professional respondents AGREE to the usability of the system.

The **Reliability** of the system to which product or components performs specific functions under specified conditions for a particular period of time. The determined average mean is 4.11 which results that the professional respondents AGREE to the reliability of the system.

The **Security** of the system to which a product or system protects information and data so that persons or other products or systems have the degree of data access appropriate to their types and levels of authorization. The determined average mean is 4.04 which results that the professional respondents AGREE to the reliability of the system.

The **Portability** of the system to which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another. The determined average mean is 4.33 which results that the professional respondents AGREE to the portability of the system.

The **Maintainability** of the system to which a product or system can be modified to improve it, correct it or adapt it to changes in environment, and in requirements. The determined average mean is 4.22 which results that the professional respondents AGREE to the maintainability of the system.

After all, the summation of the overall average of the system is 4.22 out of 5. This shows that the professional respondents AGREE to the characteristics, performance, and overall aspects of the system. This qualifies the system for ISO/IEC software and quality.

CONCLUSION AND RECOMMENDATION

The final result of the study shows that the Solar Powered Automated Waste Restraining Device for Sewages has reached and achieved its full functionality requirements. The respondents of Barangay Juliana, San Fernando, find the device reliable as it gets the job done, effective as it produces the intended results, and sustainable as it maintains its goal.

Whereas the evaluation of the three (9) professionals clearly states that the device was ready as it passed the required overall average aspects.

Assessing all the results, for the future researchers who want to continue and improve the study, these are the endorsements of some residents in Barangay Juliana; to extend the restrainer so that it can accumulate more waste, add a water pump to make a better flow of water which can trap more trash inside it. It is also recommended to add a security mechanism since the device will stay outdoors at canals.

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