Portable waste bank for plastic bottles by weight and bottle categories

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Abstract. Garbage is basically a material that is wasted or disposed of from a source resulting from human activities or natural processes that have no economic value, and can even have a negative value if it is not handled properly. Of the various kinds of waste that exist, one type of waste that can still be reused is plastic bottle waste. This study discusses the design and manufacture of a portable plastic bottle waste bank that provides sales value automatically through measuring the weight of plastic bottles using Arduino software. This plastic bottle waste bank tool is designed with the feature of automatic sales value acquisition through the acquisition of scale calibration data and determination of bottle categories measured using an IR sensor. The plastic bottle waste bank system is set using the Arduino Uno program to obtain the calibration factor from the load cell sensor. The test results show that the calibration factor with a value of 701 shows the smallest error percentage value and the average weight of the measuring stone is close to the actual value with the average data collection variable in one experiment of 5. Testing on this waste bank tool is quite good because the tool able to provide categories and selling prices of plastic bottles based on a given programming function. However, this tool still lacks in the accuracy of calibration on the scales.

1. Introduction

Garbage is basically a material that is wasted or disposed of from a source resulting from human activities or natural processes that have no economic value and can even have a negative value if it is not handled properly [1].

The waste problem in Indonesia is a problem that has not been resolved until now. Meanwhile, with the increase in population, it will also follow the increase in the volume of waste generated from human activities [2]. Efforts to preserve the environment must start from the individual by starting by doing small things. Changes made can then be ‘transmitted’ into habits in the family or society, resulting in major changes. Changes in people’s way of thinking about household waste management to reduce waste at the source through citizen participation must be integrated into the waste bank project [3].

Several government regulations have been issued for waste management so as not to harm humans. Some of these regulations include Law Number 18 of 2008 concerning Waste Management, now it is necessary to change the public’s perspective on waste and how to treat or manage waste. The public’s perspective on waste should no longer see waste as useless waste. Waste should be seen as something that has use value and benefits. In order to implement Government Regulation no. 81 of 2012 concerning the Management of Household Waste and Similar Waste to Household Waste, the practice of processing and utilizing waste must be a real
step in managing waste. People have to leave the old way of just disposing of waste by educating
and familiarizing people with sorting, choosing, and appreciating waste as well as developing a
people's economy through the development of portable waste banks, so as to create a 3R
(Reduced, Reused, Recycled) culture for a better life [3].

Of the various kinds of waste that exist, one type of waste that can still be reused is plastic
waste, namely by recycling. By being able to recycle, there is a lot of potential from plastic waste
that can still be utilized. To support this step, a tool design for processing waste is made to reduce
volume and increase selling power which will later be deposited in a waste bank [4].

Based on data from the Ministry of Environment and Forestry (KLHK), national waste
production reached 35.4 million tons as of April 2021, of which 18.46 percent was plastic waste.
For example, in DKI Jakarta, according to data from the Ministry of Environment and Forestry
(KLHK) it is stated that the people of DKI Jakarta dispose of around 151,863.28 tons of waste
per month and 5,062.10 tons per day spread over 1,290 places that temporarily accommodate
waste. The waste consists of organic waste and inorganic waste [5].

The selection of plastic waste is done because of the nature of the plastic waste itself which is
quite difficult to decompose and takes a long time compared to other types of waste so that in this
final project the author makes a design tool that can be used to collect waste with the type of
plastic bottle where the garbage Plastic bottles that have been collected can be processed properly
and can reduce the waste that is around so as not to pollute the environment.

Based on Aprilia's research, he designed a plastic bottle bank machine using RFID (Radio
Frequency Identification) as an activator and received the selling value of plastic bottles. The
machine uses RFID, loadcell sensors, servo motors, LCD Touchscreen, and Arduino Mega 2560
as the central control system [6]. Mufti's research designed a smart trash that can weigh garbage,
computer-based waste identification and data that is directly stored in a database. The components
used in the design of the machine are QR code, loadcell sensor, and Arduino Uno in terms of
weighing waste and identifying waste [1]. Atmajaya's research designed a microcontroller-based
non-organic waste scale control system displayed on an LCD screen to be processed into a
portable waste bank system [7].

Through this background, a portable plastic bottle waste bank was designed to provide a
selling price for plastic bottle waste. This study has similarities with the work of the journal
Aprilia et al. Therefore, in this research, it is designed to determine bottle category using a sensor.
The machine is designed to look like an ATM machine. Users need to enter used plastic bottles
to obtain bottle weight data and obtain the results of selling the bottle. Bottle weight is a
consideration in awarding a nominal number of rewards given through e-wallets or electronic
moneys.

2. Methodology
This study discusses the design and manufacture of a portable plastic bottle waste bank that
provides sales value automatically through measuring bottle weight using Arduino. The design of
this tool includes the design of hardware and software.

2.1. Flowchart Diagram
The flow chart is shown in Figure 1. The analysis of the research flow chart consists of the
following stages:
1. Problem Identification
   Problem identification from this research is explained in the background by focusing on
   obtaining accurate used plastic bottle data so that it can determine sales value automatically.
2. Needs Analysis
   At this stage, it is carried out to overcome the problems faced from each handling carried out
   in the first stage. The requirements that can be determined can be related to the needs of the
tool components that make up the design of the waste bank system.
3. Designing Machine
   The design of the tool in this study consisted of two parts, namely software (software) and
   hardware (hardware). Software (software) through the Arduino IDE software to compile a
   program that makes it easier to initialize a series of programs created. Hardware through
several components such as Arduino Uno, HX711, IR (Inframred) sensor, servo motor and loadcell sensor. The hardware design uses a layout with a pin function that will be connected to the components needed to serve the microcontroller.

![Flowchart diagram](image)

**Figure 1. Flowchart diagram**

4. Data Processing
   The categories of data obtained through testing are loadcell calibration tests based on a given load, the success of weight testing is based on the accuracy of the data obtained and the plastic bottle reading test program. The formula used to calculate accuracy based on the proportion of success and error of the tool:

   \[ \text{Percentage of Success} = \frac{\text{Read}}{\text{Actual}} \times 100\% \quad (1) \]

   \[ \text{Error Percentage} = \frac{\text{Actual} - \text{Read}}{\text{Actual}} \times 100\% \quad (2) \]

   \[ \text{Average} = \frac{n}{N} \times 100\% \quad (3) \]

5. Analysis and Discussion
   At this stage, analysis and discussion of the results of the data obtained from the design of the tool and calculations from data processing is carried out.

6. Conclusions
   At this stage, make conclusions from data processing that has been analyzed and discussed and provide suggestions for improvement for the design of the next tool in the future.

2.2. Block diagram
   The block diagram of the system is a description of the working principle of the circuit as a whole. Figure 2 is a block diagram of the machine hardware circuit design.

![Block diagram](image)

**Figure 2. Block diagram of hardware tool design**
Input is analog data from load cell sensor and IR sensor. The data from the load cell sensor will be extracted by the HX711 module to calculate the weight of the plastic bottle and processed onto the Arduino Uno board. The IR sensor in the form of digital data provides information to the Arduino Uno board in the form of bottle categories to determine the size of the plastic bottle. The data on the weight and size of the bottles that are processed on the microcontroller are calculated for the sales value and forwarded to the serial monitor to show the sales value of the plastic bottles.

2.3. Plastic bottle waste bank flowchart
The main program flow chart for the used plastic bottle weight measurement tool is shown in Figure 3 as follows:

![Figure 3. Waste bank machine flowchart](image)

The system of this portable plastic bottle waste bank tool starts from the entry of plastic bottles into the tool hole and machine calibration through the detection of IR (infrared) sensors. The detected bottle weight is then weighed with a load cell sensor and continued to the microcontroller for processing the appearance of the weight data on the serial monitor. Analog data from load cell
is extracted via HX711 for transfer to Arduino Uno. The bottle weight data received is in a state not filled with water. The bottles given are categorized using IR sensors and load cell sensors which are used to determine whether the bottle category is large, medium, or small. Bottle category data helps in determining the fair weight of each bottle category. If the plastic bottle has an unusual size based on its category, the user is asked to repair the bottle given first. After the bottle weight is read from the load cell sensor and processed, the value from the sale can be obtained which is displayed on the serial monitor screen. Additional used plastic bottles are put back into the hole processed back to the calibration stage.

3. Results and Discussion

3.1. Garbage bank design
In the process of making the prototype of this portable plastic bottle waste bank, a design process was carried out first using the Autodesk Inventor Professional 2022 software to determine the appropriate design for the tool to be made. In the manufacturing process there are several aspects that are considered in the manufacturing process such as the tool frame that functions as infrastructure and the foundation where the tool components will be placed. To get precise and optimal results for the manufacture of the frame, a design was first made with the help of Autodesk Inventor Professional 2022 software. Figure 4 is the design of a portable plastic bottle waste bank using the Inventor Professional 2022 software.

![Figure 4. 3D design plastic bottle waste bank front view](image)

Figure 4. 3D design plastic bottle waste bank front view

Figure 5 is a prototype of a portable waste bank tool that has been made based on the design of the Inventor Professional 2022 software.

![Figure 5. Portable prototype of plastic bottle waste bank](image)

Figure 5. Portable prototype of plastic bottle waste bank
3.2. Load cell calibration on scales

The value of the calibration factor is obtained by changing the float calibration factor in the program by increasing or decreasing the value of the calibration factor until the value of the calibration factor is close to the value of calibrated weighing. The code used in the calibration process can be seen in Figure 6.

![Calibration code for load cell](image)

Figure 6. Calibration code for load cell

In the process of this trial, 3 values were obtained that were close to the calibrated weighing, namely the calibration factors of 700, 701 and 702. The calibration experiment was carried out three times to get values that were close to the weight of the load cell sensor of 10 grams, 20 grams, and 50 grams.

The results of the first experiment with a load of 10 grams which can be seen in Figure 7 show that the value of the weight calibration factor of the load cell sensor with a value of 701 is the chosen one because the weight of the load cell sensor obtained is almost close to 10 grams with a weight of 9.66 grams and an error value is also obtained. the smallest at 3.42% compared to the other two factors, namely 700 and 702.

![Average weight and percentage of load cell error 10 grams](image)

Figure 7. Average weight and percentage of load cell error 10 grams

The results of the second experiment with a load weight of 20 grams which can be seen in Figure 8 show that the value of the weight calibration factor of the load cell sensor with a value of 701 is the chosen one because the weight of the load cell sensor obtained is almost close to 20 grams with a weight of 19.66 grams and an error value is also obtained. the smallest at 1.72% compared to the other two factors, namely 700 and 702.
The results of the third experiment with a load weight of 50 grams which can be seen in Figure 9 shows that the value of the weight calibration factor of the load cell sensor with a value of 701 is the chosen one because the weight of the load cell sensor obtained is almost close to 50 grams with a weight of 49.09 grams and an error value is also obtained. the smallest of 1.83% compared to the other two factors, namely 700 and 702.

In this case, it can be concluded that a load cell with a calibration factor of 701 will be used as a factor that will affect the weight of each plastic bottle that is inserted into the portable plastic bottle waste bank.

3.3. Comparison of the number of variables $i$

After the comparison of the calibration factors, the affect the weight of the plastic bottle, then a comparison is made variables $i$. The variable $i$ is the amount of weight data that is averaged for knowing the amount of data that must be taken in the weighing process plastic bottle weight.

The process to determine the amount of variable $i$ is carried out by experiment 5 trials each for each factor were averaged. The amount of variable $i$ used is 5, 10 and 15, meaning the program will read the variable according to the size of the input variable $I$ in the program as shown in Figure 10.
Experiments that have been carried out using plastic bottles weighing 10 grams, 15 grams, and 31 grams as a weighting factor to determine the amount of variable $i$ with the number of experiments every 5 times. The results of the first experiment using a 330 ml Aqua bottle and a bottle weight of 10 grams which can be seen in Figure 11 shows that the variable $i = 5$ was chosen because it has a plastic bottle weight that is obtained almost 10 grams with an average weight of 10 plastic bottles, 12 grams and obtained a variable percentage error of 1.17%.

The results of the second experiment using a 600 ml Aqua bottle and a bottle weight of 15 grams which can be seen in Figure 12 shows that the variable $i = 5$ was chosen because it has a plastic bottle weight that is obtained almost 15 grams with an average weight of 15 plastic bottles, 18 grams and also obtained a variable percentage error of 1.17%.

The results of the third experiment using a 1500 ml Aqua bottle and a bottle weight of 31 grams which can be seen in Figure 13 shows that the variable $i = 5$ was chosen because it has a
plastic bottle weight which is almost 31 grams with an average weight of 30 plastic bottles, 77 grams and obtained a variable percentage error of 0.75%.

Figure 13. Average weight and error percentage of plastic bottles 1500 ml (31 grams)

In this case, it can be concluded that the variable \( i = 5 \) will be used as the amount of data that must be taken by the program which will later be used in the Arduino Uno program.

3.4. Sum of selling prices and categories of plastic bottles

The results of the experiment can be seen in Table 1. The 5 times the experiment was carried out showed a difference in price from each time the experiment was carried out even though the bottles used were the same, this could happen because the position of the scales was not balanced when the scales returned to the initial position so that it could affect the weight of the plastic bottle itself.

From Table 1 it can be seen that in terms of category it is appropriate to the type of bottle being measured. The results of the weight reading are processed for testing the accuracy and feasibility of a portable plastic bottle waste bank. The results of testing the accuracy and feasibility of the tool are shown in Table 2.

Table 1. Bottle measurement reading data by category

| Trial | Bottle Type | Bottle Category | Total Bottle Sales Price | Selling Price 1 Bottle | Bottle Weight |
|-------|-------------|-----------------|--------------------------|------------------------|---------------|
| Trial 1 | Aqua Bottle | 1500 ml | 261.25 | 261.25 | 685.98 |
| Trial 2 | Aqua Bottle | 1500 ml | 261.25 | 261.25 | 685.98 |
| Trial 3 | Aqua Bottle | 1500 ml | 261.25 | 261.25 | 685.98 |
| Trial 4 | Aqua Bottle | 1500 ml | 261.25 | 261.25 | 685.98 |
| Trial 5 | Aqua Bottle | 1500 ml | 261.25 | 261.25 | 685.98 |

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Testing the accuracy and feasibility of the tool

Table 2. Testing the accuracy and feasibility of the tool

| Trial | Bottle Type | Aqua Bottle 1500 mL | Aqua Bottle 1500 mL | Aqua Bottle 1500 mL | Aqua Bottle 1500 mL | Aqua Bottle 1500 mL | Aqua Bottle 1500 mL | Aqua Bottle 1500 mL | Aqua Bottle 1500 mL |
|-------|-------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Trial 1 | Fail | 84% | 90% | 87% | 100% | 110% | 110% | 100% | 100% | 100% |
| Trial 2 | Fail | 84% | 89% | 87% | 100% | 110% | 110% | 100% | 100% | 100% |
| Trial 3 | Fail | 84% | 89% | 87% | 100% | 110% | 110% | 100% | 100% | 100% |
| Trial 4 | Fail | 84% | 89% | 87% | 100% | 110% | 110% | 100% | 100% | 100% |
| Trial 5 | Fail | 84% | 89% | 87% | 100% | 110% | 110% | 100% | 100% | 100% |

3.5. Percentage of plastic bottle experiments succeed

The results of the trials can be seen in Table 3, from 63 trials that have been carried out with 18 failures and 45 bottles successes that can be calculated and produce results in the form of plastic bottle weight in grams, the unit price of plastic bottles, total sales in rupiah, and the bottle category that is measured, the percentage of failure is 29% and the percentage of success is 71% which can be seen in Figure 13. Table 3 is the data on the number of failures and successes carried out in the process of testing the portable plastic bottle waste bank tool as follows:

Table 3. Number of trials of portable plastic bottle waste bank tools

| Information | Fail | Succeeded | Total |
|-------------|------|-----------|-------|
| Trial 1     | 7    | 9         | 16    |
| Trial 2     | 3    | 9         | 12    |
| Trial 3     | 0    | 9         | 9     |
| Trial 4     | 4    | 9         | 13    |
| Trial 5     | 4    | 9         | 13    |

Total: 18 45 63

Figure 14 is the percentage of success and failure in the process of testing the portable plastic bottle waste bank tool as follows:

Figure 14. Percentage of success and failure of plastic bottle experiments
The failure factor that has been done occurs because the Arduino Uno program does not accept input from the IR sensor, so the IR sensor cannot read the category from the incoming bottle. The next failure factor occurs because the bottles are not included in the programming category, for example, if the weight of the bottle with category 1 weighs 7-13 grams and the plastic bottle inserted into the portable plastic bottle waste bank is more than or less than the weight of category 1 then running program will reject the bottle.

The first solution that can be given to reduce errors is to design the model of the scale so that it does not change its position when the scale returns to its initial position. Second, it uses a more precise loadcell sensor for the gram scale so that more accurate data can be obtained.

4. Conclusions
In this work, the design of the waste bank machine can be run using an Arduino whose settings are obtained from the IR sensor, load cell sensor, servo motor, and the results of the experiment are displayed on the serial monitor. The results of the calibration factor test with a value of 701 provide the smallest error percentage value and have a measuring value close to 10 grams, 20 grams, and 50 grams so that it will be used in Arduino Uno programming. Testing on the portable plastic bottle waste bank tool can be used because the plastic bottle waste bank portable tool can provide categories based on the programming function provided and provide a selling price based on each category.

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