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Regional Case Study

Inorganic Waste Reduction Planning with The Implementation of Dipo Waste Bank (DWB) and Reverse Vending Machine (RVM) at Diponegoro University

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Abstract

Plastic waste is a global environmental problem that has existed for a long time and has not been resolved. On a worldwide scale, solid waste increased to 9.1 billion tons, of which 6.9 billion tons was plastic waste. Undip is one of the largest public universities. As one of the universities that supports the achievement of SDGs Number 12 concerning waste management, Diponegoro University has a Waste Bank, namely the Dipo Waste Bank (DWB). The method used in this study is mass balance. Based on the projected waste generation from 2021-2030, the era of inorganic waste in the composition of plastic bottles at Undip is 42,577 kg/day. DWB is expected to realize independent and sustainable waste management within Diponegoro University (UNDIP). In its course, waste management efforts are felt to be lacking due to several obstacles and participation that are not optimal. There are three scenarios of reducing inorganic waste of plastic bottles in the study, namely the baseline scenario, the Dipo Waste Bank (DWB) scenario can achieve the target of 20% of waste that can be recovered by DWB and Reverse Vending Machine (RVM).

Keywords: Reverse Vending Machine (RVM); Undip; Dipo Waste Bank (DWB)

1. Introduction

Plastic waste is a global environmental problem that has existed for a long time and has not been resolved. On a worldwide scale, solid waste increased to 9.1 billion tons, of which 6.9 billion tons were a plastic waste (Merino & Ayer, 2018). Based on data from the Ministry of Environment and Forestry in 2018, plastic waste ranks second most of all types of waste, reaching 12.4%. It is estimated that 12 billion tons of plastic waste will end up in landfills and in the natural environment by 2050 (Geyer et al., 2017), along with greenhouse gas (GHG) emissions from the entire plastic life cycle that contribute to 15% of the total global carbon budget (Zheng & Suh, 2019). One of the plastic packaging that is widely found, namely the use of plastic bottles, which is increasingly rampant among the public. According to the World Atlas, Indonesia is the fourth country that uses the most plastic bottles globally. It is recorded that the use of plastic bottles in Indonesia has reached 4.82 billion (Anita & Subaidillah, 2019). In addition, using plastic bottles has a terrible impact on the environment. Plastic bottle waste is complicated to decompose and accumulates, causing hygiene and environmental health problems. According to the Ministry of Health, in 2016, nearly 3 million tons of plastic waste worldwide came from single-use plastic drinking bottles, each taking approximately 100 years to decompose (Ministry of Health, 2016).

One of the efforts to handle plastic waste that has been carried out in Indonesia, namely the existence of a Waste Bank that applies 3R (Reduce, Reuse, Recycle) in waste management at its source with an incentive pattern to the community (Makmur S, 2016). The waste bank is a community-based waste management method as an approach to waste management based on the active participation of the community. As one of the universities that supports the achievement of SDGs Number 12 concerning waste management, Diponegoro University has a Waste Bank, namely the Dipo Waste Bank (DWB) where this campus waste bank was established to serve the active contribution of the Diponegoro University Academic Community (CAK UDI) in waste management on campus. DWB is expected to realize independent and sustainable waste management within Diponegoro University (UNDIP). In its activities, DWB will collect an-organic waste deposited by CAK UDI. The collected waste will be sorted and sold to collectors according to their type. The proceeds from selling this waste will be savings for DWB waste bank customers. Waste savings that have been converted into rupiah will be able to be taken or donated by customers in cash or book transfers.

Dipo Waste Bank managers are Diponegoro University students who form an UKM (Student Activity Unit) and go through a recruitment process. This UKM also plays a role in organizing Dipo Waste Bank events for the entire academic community of Diponegoro University. In addition, Dipo Waste Bank (DWB) have collaborated with businesses around the campus such as grocery stores, places to eat, or mini markets. Weighing locations are still moving to several locations, but several other locations already have permanent booths in the form of container booths. Waste stations in period 3 are only located in units that have the most active customers.

The Waste Collecting Center or the final waste collection point began to be formed in this period which is planned to be located behind the Joint Lecture Building, Faculty of Engineering, Diponegoro University with a permanent building form. The size of the building is 6m x 7m. However, the collection point is still unable to operate during this period. Regarding the sale of waste, it is still the same as before, it is still sold to collectors but has begun to prepare for cooperation with the company so that the waste can be sold directly to the company. In period 3, it has also prepared waste processing such as the manufacture of plastic seeds so that the selling value is higher. The garbage received has become 8, namely the addition of cans and iron waste.

However, community-based waste management programs like waste banks often fail due to low community participation. If waste management is not considered necessary, it will impact participation and low willingness to pay. This problem also occurs in the Dipo Waste Bank (DWB), so it becomes ineffective. The waste recording is still done manually, and customer waste receipts can only be done on certain days (1 receipt per month). Then, customers who save waste there do not sort out their plastic bottles, so plastic bottles mix with other garbage, and the possibility of getting dirty is enormous. The quality factor of plastic bottles (dirty, still have labels, contaminated with other materials) will significantly affect the price and can even eliminate the selling value. Therefore, plastic bottles must be re-sorted from other waste, cleaned, and sorted manually by the waste bank to get quality plastic bottle waste. This is considered very ineffective because it adds time and cost to operate the waste bank for the processing process.

Based on the potential and problems above, an Reverse Vending Machine (RVM) Dipo Waste Bank innovation is needed. This tool serves to help Dipo Waste Bank in managing plastic bottles and make it easier for customers who want to save their waste, especially plastic bottle waste. Database Management, which will be applied to the Reverse Vending Machine system, will help record or calculate the amount of plastic bottle waste on DWB. For weighing systems from plastic bottles, in the "name of our tool," several sensors are integrated with the Raspberry Pi microcontroller. With the "name of our tool", it is hoped that it can facilitate the management of plastic bottle waste for DWB and attract undip residents to dispose of waste.

2. Methods

The analysis method used in this study is a mass balance analysis. The mass balance analysis in this study was used to determine the volume of waste generation and the composition of waste, which will later be known what percentage of waste can be reduced at Undip Integrated Waste Disposal Site (TPST) from the total volume of waste generation waste in Integrated Waste Disposal Site (TPST) Undip.

This study used sampling data from the previous study, where the number of sample samples could be determined by calculating SNI 19-3964-1994, using data from interviews from questionnaires. In addition, interview data and questionnaires also strengthened the sample data obtained from the sampling of office waste. Sampling was carried out at Integrated Waste Disposal Site (TPST) Undip with the sample location presented as follows.

The sampling period includes the semester's beginning and the semester's end. The first semester is from February to June, and the second semester is from August to December. The collection and measurement of waste samples in the education sector contain 11 faculties and two schools (vocational and post-graduate). The office sector includes Widya Puraya (WP), SA-MWA, ICT, ICC, Student Activity Center (PKM), and Cooperatives. The supporting sector includes various parts that support educational or office activities at Undip, such as the centre training, rectorate buildings, gas stations, and student dormitories.

3. Result and Discussion

3.1 Existing Conditions of Undip Waste Management

This research was conducted at Diponegoro University (Undip). This state university is located in Semarang, Central Java Province, Indonesia and is limited to the Undip campus area located in Tembalang District, which is located about 15 km south of downtown Semarang. Undip's location includes a tropical climate with relatively high rainfall and an average temperature of 27◦C. In 1957, undip had 11 Faculties and 2 Schools, 58 Undergraduate Study Programs, 32 Vocational School Study Programs, 38 Master Study Programs, 19 Specialist Medical Education Programs, 4 Professional Programs and 15 Doctoral Study Programs. Undip is also equipped with various facilities, including student dormitories, stadiums, commercial areas, educational reservoirs, and national hospitals. The main activities at Undip are in the fields of academia, research, and community service.

Table 1. Number of Diponegoro University campus residents in 2020

Campus	Sector	Information	Number of Campus Residents
Undip Tembalang	Education	Faculty of Law and Faculty of Social and Political Sciences	9,763
		Faculty of Humanities	4,086
		Vocational School	6,522
		Dept. Civil Engineering, Geological Engineering, Urban and Regional Planning Engineering, Architecture	3,957
		Dept. Environmental Engineering, Geodesy Engineering, Shipping Engineering, Computer Engineering, Industrial	6,423

Campus	Sector	Information	Number of Campus Residents
		Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering	
		Faculty of Economics and Business	3,100
		Faculty of Psychology	1,491
		Faculty of Science and Mathematics	4,701
		Faculty of Fisheries and Marine Sciences	3,995
		Faculty of Animal Husbandry and Agriculture	3,171
		Faculty of Medicine and Faculty of Public Health	7,488
	Office	Widya Puraya and SA-MWA	377
		ICT, ICC, SC, PKM, Koperasi	32
	Support	RSND	672
		Rusunawa	800
		Gas Stations	30
		Campus Mosque	398
Sum			**57,006**

In 2020, 57. 006 people are on campus every day. The number of Tembalang campus residents in the education sector in 2020 amounted to 54,697 people, while for the office sector, which amounted to 409 people, and in the office sector amounted to 1900 inhabitants. Fifty-four thousand four hundred eighty of them are students. As shown in figure 1. The division of sectors at Undip is based on grouping its activities: education, offices, and support.

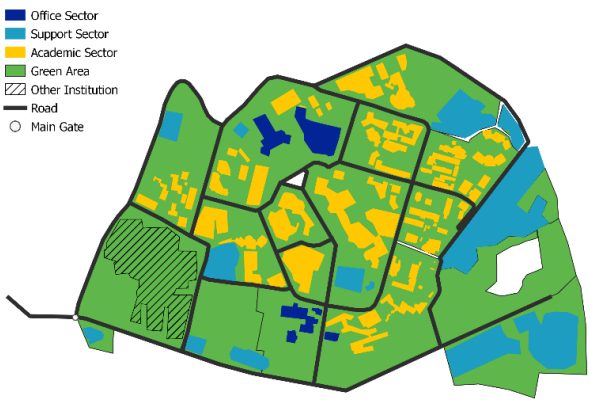


Figure 1. Case study: Undip Tembalang campus

Waste management in the Diponegoro University environment consists of waste storage activities, waste collection, and disposal at the TPS directly. Each faculty, office, or other supporting facility carries out waste collection autonomously. Especially for the Faculty of Engineering, the department carries out the collection autonomously because the buildings are spread across several

regions, but transportation will be carried out centrally. In addition to waste disposal at TPS or Integrated Waste Disposal Site (TPST), there are still cleaning managers who burn waste because the TPS is already full.

Waste processing carried out by Diponegoro University is waste processing at Integrated Waste Disposal Site (TPST) and *Pit Composting* in several faculties. Waste processing at Diponegoro University has implemented Pit Composting to process leaf waste into compost. The Faculty of Engineering, Diponegoro University, has several composting holes for leaf waste processing. Some composting holes are in the Joint Lecture Building (GKB), Electrical Engineering, Architecture, Mechanical Engineering, Urban Area Planning Engineering, and Chemical Engineering. In addition to the Faculty of Engineering, the Faculty of Science and Mathematics has also implemented it. Because of the many trees, leaf waste processing at Diponegoro University has been effective. However, it needs to be considered for processing other types of waste, such as inorganic waste. Waste processing is also expected to not only reduce waste but can generate profits or create *a circular economy*.

The amount of inorganic waste generation in this study was obtained from the last research journal, which was carried out by sampling waste for eight days for each type of waste. In addition, a sampling of inorganic waste at the Diponegoro University was carried out at Integrated Waste Disposal Site (TPST) Undip.

Table 2. Inorganic waste sampling results based on composition

Sector	kg/day						
	Newspaper	**Paper**	**Box**	**Clan**	**`Plastic Bottle**	**Glass Bottle**	**Tin**
Education	0.000045	0.001515	0.000402	0.000641	0.000515	0.000029	0.000087
Office	0.000000	0.001638	0.002472	0.001948	0.001990	0.000000	0.000000
Support	0.000498	0.000568	0.000722	0.002133	0.000703	0.002226	0.000269
Total	**0.000543**	**0.003721**	**0.003597**	**0.004722**	**0.003208**	**0.002255**	**0.000356**

The analysis of inorganic waste generation results obtained from sampling that has been carried out will be projected for 10 years from 2021 to 2030.

Table 3. Inorganic waste generation of each unit

No.	Unit	Sector	Embossement (kg/day)
1.	Faculty of Law and Faculty of Social and Political Sciences	Education	46.09
2.	Faculty of Humanities		19.29
3.	Vocational School		30.79
4.	Dept. Civil Engineering, Geological Engineering, Urban and Regional Planning Engineering, Architecture		18.68
5.	Dept. Environmental Engineering, Geodesy Engineering, Shipping Engineering, Computer Engineering, Industrial Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering		30.32
6.	Faculty of Economics and Business		14.63
7.	Faculty of Psychology		7.04

No.	Unit	Sector	Embossement (kg/day)
8.	Faculty of Science and Mathematics		22.19
9.	Faculty of Fisheries and Marine Sciences		18.86
10.	Faculty of Animal Husbandry and Agriculture		14.97
11.	Faculty of Medicine and Faculty of Public Health		35.35
12.	Widya Puraya and SA-MWA	Office	4.35
13.	ICT, ICC, SC, PKM, Koperasi		0.37
14.	RSND	Supporter	6.87
15.	Rusunawa		8.18
16.	Gas Stations		0.31
17.	Campus Mosque		4.07
Total			**282.36**

Based on the calculation results, each unit's total inorganic waste generation is 282.36 kg/day. Therefore, the highest amount of waste generation is found in unit 1 at 46.09 kg/day or 16.32% of all inorganic waste located at the Faculty of Law and the Faculty of Social and Political Sciences. Then the most negligible inorganic waste generation is found in unit 16, namely at gas stations, with a total generation of 0.31 kg/day or 0.11% of all inorganic waste generation.

Table 4. Inorganic waste generation based on composition

Unit	Sector	Newspaper	Paper	Box	Clan	Plastic Bottle	Glass Bottle	Tin	Iron
1	**Education**	0.634	21.394	5.6749	9.058	7.271	0.408	1.230	0.416
2		0.265	8.954	2.3751	3.791	3.043	0.171	0.515	0.174
3		0.424	14.292	3.7910	6.051	4.857	0.273	0.822	0.278
4		0.257	8.671	2.3001	3.671	2.947	0.165	0.499	0.169
5		0.417	14.075	3.7335	5.959	4.783	0.268	0.810	0.274
6		0.201	6.793	1.8019	2.876	2.309	0.130	0.391	0.132
7		0.097	3.267	0.8667	1.383	1.110	0.062	0.188	0.064
8		0.305	10.302	2.7326	4.361	3.501	0.197	0.592	0.201
9		0.260	8.755	2.3222	3.706	2.975	0.167	0.504	0.170
10		0.206	6.949	1.8432	2.942	2.362	0.133	0.400	0.135
11		0.487	16.409	4.3526	6.947	5.576	0.313	0.944	0.319
12	**Office**	0.000	0.885	1.3358	1.053	1.075	0.000	0.000	0.000
13		0.000	0.075	0.1134	0.089	0.091	0.000	0.000	0.000
14	**Support**	0.480	0.547	0.6956	2.054	0.677	2.144	0.259	0.020
15		0.571	0.651	0.8281	2.445	0.806	2.552	0.308	0.024
16		0.021	0.024	0.0311	0.092	0.030	0.096	0.012	0.001
17		0.284	0.324	0.4120	1.216	0.401	1.270	0.153	0.012
Total	**4.033**	**121.368**	**33.9386**	**53.941**	**42.577**	**4.431**	**7.154**	**2.352**	

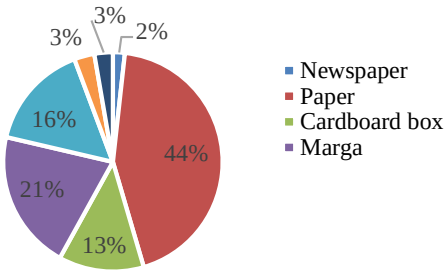


Figure 2. Composition of Inorganic Waste

Based on the picture above, it can be seen that the faculty with the most extensive inorganic waste composition is paper waste, with waste generation weighing 122,367 kg/day with a percentage of 44%. As for the composition of the minor waste, newspapers weigh 4,910 kg/day with a percentage of 2%. The percentage of plastic bottles is quite large and has a selling value, but it has not been utilized optimally in its management.

3.1. Undip Waste Management Scenario

The future waste management plan includes various strategies, as follows:

1. Undip's Integrated Waste Disposal Site (TPST) services reach 100%
2. The strategy of reducing waste at source (faculties/schistates/units) to Integrated Waste Disposal Site (TPST) (recycling , composting, burning waste) is implemented gradually through campaign and education/empowerment programs to the academic community
3. The increase in Integrated Waste Disposal Site (TPST), resulting in a decrease in waste generation by up to 20% in 2029, which has an impact on reducing the burden of landfillfill which is quite significant.

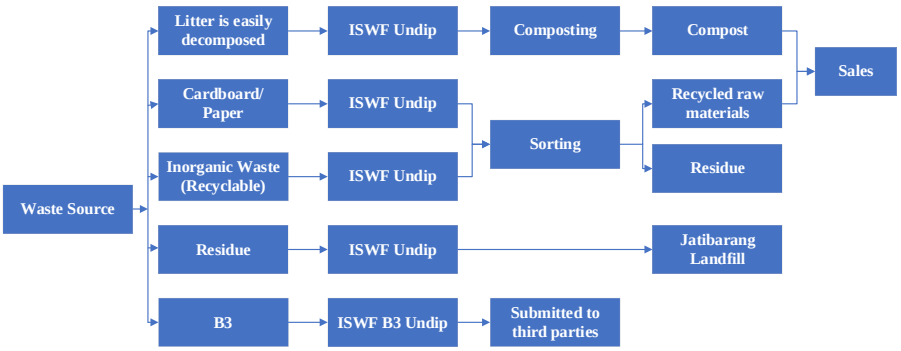


Figure 3. Waste handling scheme plan
Source : (Diponegoro University Rector's Regulation No. 32, 2019)

The analysis of waste reduction potential processed at Undip Integrated Waste Disposal Site (TPST) focuses on inorganic waste types (plastic bottles). The potential for reducing inorganic waste of plastic bottles from the activities of the education, office, and supporting sectors consists.

3.1.1. Baseline Scenarios

Waste management carried out by the Undip Tembalang campus, namely waste processing at Undip Integrated Waste Disposal Site (TPST). Undip Integrated Waste Disposal Site (TPST) has sorted and reduced types of organic and inorganic waste, but the percentage of reduction is still focused on organic waste only by utilizing it into compost and then sold. This contributes to reducing the

generation of organic waste by 81%, while the reduction of inorganic waste (plastic bottles) by sorting at Integrated Waste Disposal Site (TPST) produces a percentage reduction by 2% and residue to landfill by 17%. Sometimes waste is burned openly because of the accumulation of waste contained in Undip Integrated Waste Disposal Site (TPST). The calculation of inorganic waste reduction with the weight of plastic bottle waste is taken from the projected data of waste generation, as follows equation (1) and (2):

$$\text{Reduction Weight (kg)} = \frac{Plastic\ Bottle\ Weight\ (kg) x\ Rf}{100\%} \quad \text{.....(1)}$$

$$= \frac{42{,}577 \text{ x } 2\%}{100\%} = 0.851 \text{ kg}$$

$$\text{Unmanaged Weight (kg)} = Plastic\ Bottle\ Weight\ (kg)\ x\ Reduction\ Weight\ (kg) \text{....(2)}$$

$$= 42{,}577 - 0.851 = 41.725 \text{ kg}$$

Based on the calculations above, Integrated Waste Disposal Site (TPST) can only manage plastic bottle waste of 0.851 kg. Therefore, it is necessary to consider the management of inorganic types of waste om its onset. Waste management is also expected to not only reduce waste but can generate profits or create *a circular economy*.

3.1.2. Scenario of the Existence of an Existing *Dipo Waste Bank* (DWB)

Dipo Waste Bank (DWB) is a campus waste bank institution initiated by Undip Environmental Engineering students and lecturers and inaugurated in 2021. Since its inauguration, DWB has carried out several weighing times and has had 203 customers: students, lecturers, educators, organizations, and others. The waste received by DWB is waste that has economic value. Details of the categories of garbage and their prices can be seen in the following table.

Table 5. Categories of garbage and weight

Categories Garbage	Total Weight / Category (kg)
Box	450.96
Marga/ Duplex	337.57
Paper	499.92
Mixed paper	510.5
Plastic Bottle	**234.27**
Hard Plastics	30.7
Aluminum	15.48
Iron	3.87
Rubber	4.8
Used Cooking Oil	18.7
Additions: Glass, ...	5.3
Total Weight (Kg)	**2112.07**
Total Revenue (Rp)	**3179033**

Based on the table above, DWB can collect plastic bottles from customers amounting to 234.37 kg with 13 times the receipt of waste that has been done. In addition, DWB weighs once a month so that DWB can collect 0.709 kg/day of plastic bottles. Reduction bottles following equation (3)

$$\text{Reduction Weight (kg)} = \frac{Plastic\ Bottle\ Weight\ (kg)\ x\ Rf}{100\%} \quad \text{.....(3)}$$

$$= \frac{42{,}577 \text{ x } 16\%}{100\%} = 6.81 \text{ kg}$$

The percentage of plastic bottle waste reduction with the DWB scenario is 16%. In addition, plastic bottles can be sold to collectors who later get income from the sale. The total revenue owned by DWB in the last weighing in July 2022 was IDR 3,179,033.

3.1.3. Enhanced yang Scenario Dipo Waste Bank and Reverse Vending Machine

In its implementation, the Dipo Waste Bank (DWB) scenario has not been able to meet the target and has not been optimal in reducing plastic bottle waste at Undip. In addition, the receipt of waste from customers can only be done at Undip Integrated Waste Disposal Site (TPST). Moreover, at certain times causes this to be collected plastic bottle waste is not optimal.

With this scenario, the concept of collecting plastic bottle waste will be facilitated, where customers can save their waste anywhere and anytime while in the Undip area. This scenario involves a Reverse Vending Machine (Reverse Vending Machine (RVM)) tool, which can later only accept plastic bottles. The plan with this scenario can reduce the generation of plastic bottle waste from the source by 4% of the total plastic bottle waste.

Reduction Weight (kg) (Reverse Vending Machine (RVM))

$$= \frac{Plastic\ Bottle\ Weight\ (kg)\ x\ Rf}{100\%}$$

$$= \frac{42{,}577\ \text{x}\ 4\%}{100\%} = 0.106\ \text{kg}$$

So that with this DWB and Reverse Vending Machine (RVM) scenario, it was found:

Reduction Weight (kg) (Reverse Vending Machine (RVM)+DWB = $\frac{Berat\ Sampah\ Botol\ Plastik\ (kg) x\ Rf}{100\%}$

$$= \frac{42{,}577\ \text{x}\ 20\%}{100\%} = 8.515\ \text{kg}$$

The percentage of plastic bottle waste reduction with DWB and Reverse Vending Machine (RVM) scenarios is 20%. With this scenario, the plastic bottles collected in the Reverse Vending Machine (RVM) will be directly handed over to the collector or company without sorting and weighing at a particular time and place when DWB receives waste from customers.

3.2. Technical Management Using Enhanced Scenarios

A reverse Vending Machine is where users can dispose of plastic bottle waste for recycling. In this case, the user enters a bottle and gets credit points that can be converted into money. The machine's primary functions include bottle reception, bottle detection, bottle pressing, bottle storage, and DWB party warning when the machine is complete. The proposed system also uses monitoring techniques in the form of telegram notifications to get the latest information about the machine. This can help DWB customer to get information about the machine Reverse Vending Machine (RVM).

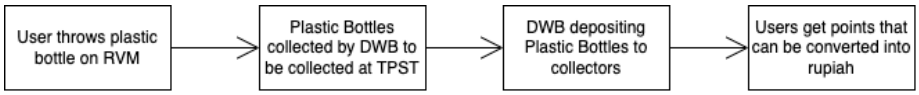


Figure 4. Mechanism of Reverse Vending Machine (RVM)

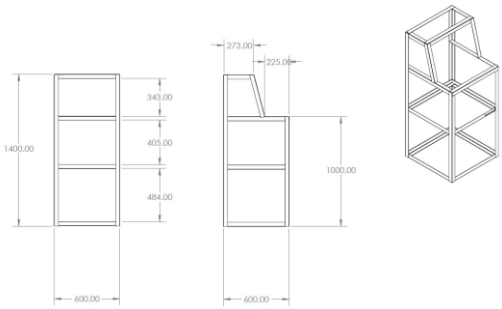
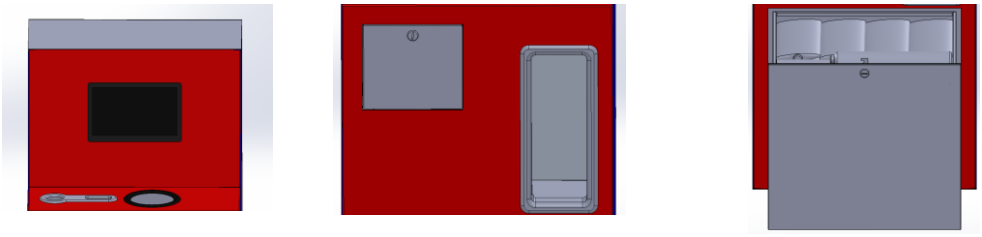


Figure 5. Initial frame of Reverse Vending Machine (RVM)

The frame of this tool is made of 4x4cm L iron with a thickness of 1 mm, which is assembled in such a way that it forms a machine frame measuring 140x60x60 cm. Each connection on the frame is connected by welding.



(a) (b) (c)

Figure 6. (a) The upper part of the Reverse Vending Machine (RVM), (b) the middle part of the Reverse Vending Machine (RVM), (c) the lower part of the Reverse Vending Machine (RVM)

At the top are three holes for caps, labels, and plastic bottles. In the bottle hole, there is a closing mechanism that can prevent foreign objects from entering the bottle scanning area. As a medium of interaction between technology products and users, there is a 7-inch LCD screen that displays the QR code, the number of bottles inserted into the tool, and the number of points earned by the user. The press mechanism on this machine is in the middle. Bottles that have been scanned by image processing will be pressed using a linear actuator, and after the bottle becomes flat, it will fall into the shelter. If the bottle does not comply with the provisions, the bottle will be automatically pushed out by the linear actuator to be returned to the user. The plastic bottle storage container uses a hollow iron frame shaped into a box, and there is a sliding door mechanism to make it easier to take plastic bottles from technology products.

The press mechanism on this machine is in the middle. Bottles that have been scanned by image processing will be pressed using a linear actuator and after the bottle becomes flattened it will fall into a shelter. If the bottle does not comply with the provisions, the bottle will be automatically pushed out by the linear actuator to be returned to the user.

Plastic bottle shelters use hollow iron frames formed by boxes and there is a sliding door mechanism to facilitate the retrieval of plastic bottles from technological products.

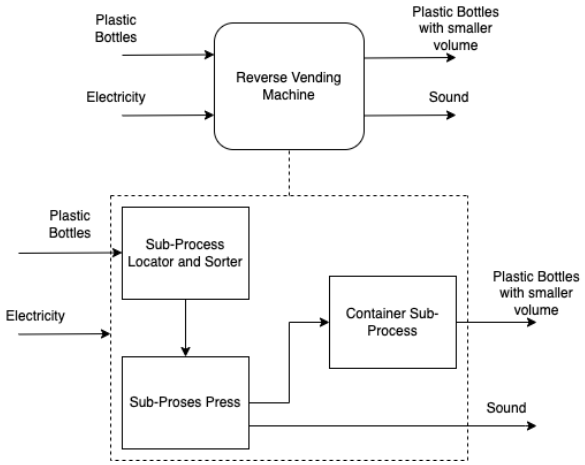


Figure 7. Sub-process Division on Reverse Vending Machine (RVM)

In this concept, the location for collecting plastic bottle waste with Reverse Vending Machine (RVM) will later be integrated with a website that will present data and as an initial stage for customers to register and access Reverse Vending Machine (RVM). Prospective customers can register through the https://dipowastebank.com/ website and fill in their data on the registration page. After registering,

customers will get a verification email stating they have successfully become customers. The schedule and location of the deposit will be informed on the website. Recording data and savings accounts and balances can be accessed through the website and viewed at any time. Taking the money from the sale can be done after three months of saving.

4. Conclusions

Based on undip's waste management plan in 2019. Undip has a target of waste processing or reducing waste processing by 20%. Undip's waste management with DWB and Reverse Vending Machine (RVM) scenarios, shows the results that Undip can achieve the target of 20% of waste that can be recovered by DWB and Reverse Vending Machine (RVM).

References

Aufa, A., Sumiyati, S., Budihardjo, M., Ramadan, B., Salman, H., Wirawan, R. 2021. Improving Recycling Behaviour Through Waste Bank Implementation in Diponegoro University. Final Project of the Department of Environmental Engineering

Diana, A. and Subaidillah F. 2019. Training on the Use of Plastic Bottle Waste as An Environmentally Friendly Paving Block Mixture : Jurnal Abdiraja. 2 (1) : 1

Diponegoro University Rector's Regulation. 2019. Waste Management Regulations through Waste Banks. Diponegoro University Rector's : Semarang

Geyer, R., Jambeck, J.R., Law, K.L., 2017. Production, Use, and Fate of All Plastics Ever Made. Science Advances. 3, e10700782.

Merino, V., dan Ayer, D. 2018. Plastic Pollution Primer and Action toolkit: End Plastic Pollution. Earth Day Network.

Mufti, Mufti, and Indra Indra. 2016. Design and Build a Smart Trash Bin Weighing And Recognizing The Type Of Waste In Budi Luhur Waste Bank. Budi Luhur Information Technology. 13 (2) : 25-29

National Standardization Agency. 2008. SNI 19-3242-2008, Concerning Waste Management in Settlements. National Standardization Agency : Jakarta

Regulation of the State Minister of environment of the Republic of Indonesia Number 13 of 2012 concerning Guidelines for the Implementation of Reduce, Reuse, and Recycle through Waste Banks

Selomo, M., Birawida, A., Mallongi, A., Muammar., M. 2016. Waste Bank as One of the Solutions for Handling Waste in Makassar City. Journal of MKMI. 12 (4) : 233.

Zheng, J., Suh, S. 2019. Strategies to Reduce the Global Carbon Footprint of Plastics. Natural Climate Change Journal. 9 (1) : 374–378.