ANALYSIS OF THE CIRCULAR ECONOMY'S IMPLEMENTATION AT MAGGOT HOUSE MENGGER SUB-DISTRICT BANDUNG CITY

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Abstract

In 2023, the city of Bandung faced serious problems because the Sarimukti landfill caught fire and the city of Bandung experienced a "waste emergency". One of the programs launched is the construction of maggot houses in every sub-district in Bandung City with a target of processing 1 ton of organic waste/day. Mengger Sub-district is one of the sub-districts that received assistance to build maggot house. The land area of the maggot house is 150 m^2, managed by 4 officers. This study aims to identify various problems that must be resolved first so that the circular economy concept can be implemented at the Mengger Maggot House. The study was carried out by conducting observations, detailed surveys and in-depth interviews with various stakeholders in Mengger Sub-district. Observations were carried out to see the level of compliance of residents in sorting, a detailed survey was carried out on the waste collection and processing system at the maggot house, and in-depth interviews were conducted with assistants from Bandung City Environmental Service Office (DLH), maggot buyers, sub-district officials, maggot house officers, neighbourhood (RT) and hamlet (RW), and waste collector. Based on the results of observations, it was found that only some residents carry out sorting consistently, a collection system already exists in each RT/RW but they have not implemented a segregated waste collection system, and there is no system for transporting waste from the RW to the maggot house so that the amount of organic waste entering the maggot house is still low, no electricity and clean water, no choppers, leaks in the fly cage, and no diversification in maggot products. Through various socialization activities and Focus Group Discussions with all stakeholders, various agreements were obtained to resolve various problems at the Mengger Maggot House.

Keywords: *diversification, maggot, mengger, organic waste, waste collector*

Introduction

Bandung City, Cimahi City, Bandung Regency, and West Bandung Regency faced severe waste management issues after the Sarimukti landfill burned down in 2023 and was unable to receive waste shipments. As a result, waste piles up everywhere throughout the city of Bandung and its surroundings. A "Waste Emergency" has been declared by the West Java Provincial Government and also the Bandung City Government (CNN, 2023). When the Sarimukti landfill was reopened, a regulation was made that organic waste was not accepted at the

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Sarimukti landfill. Thus, actions must be taken to minimize organic waste at its source. One of the initiatives is to build maggot houses in each of Bandung City's subdistricts, with the goal of digesting one ton of organic waste every day (Diskominfo Kota Bandung, 2024).

An examination of Indonesia's waste composition shows that organic waste makes up the majority—more than 70%—of the total. Depending on the community's economic class, the amount of kitchen organic waste in this garbage might range from 20 to 65% (Damanhuri, 2005; Zahra & Damanhuri, 2011). The presence of organic waste causes the garbage to decompose more quickly, which results in an unpleasant smell. Utilization of larval Black Soldier Flies (BSF) has been developed as one of the many kinds of organic waste processing (Rochaeni et al., 2022; Mulyatna et al., 2022). The insect known as the Black Soldier Fly (BSF), Hermetia illucens, is a member of the subfamily Hermetinae of the Family Stratiomyidae of the order Diptera. Because BSF has high protein (Mutafela, 2015) and nutritional levels, it is currently used extensively as animal feed(Barragan-Fonseca et al., 2017; Cheng et al., 2017).

By BSF, the proportion of organic waste reduction value ranges from 62.68% to 73.98% (Diener et al., 2015; Eawag, 2017). These results vary because there are differences in treatment in feeding BSF larval. The harder the characteristics of the waste given to the BSF larval, the more difficult the reduction process will be (Rochaeni et al., 2021). In addition, humidity, temperature, and media type greatly influence the growth of BSF (Barragan-Fonseca et al., 2017; Mulyatna et al., 2022). In addition to the ability of BSF larval to reduce waste, the final stage of larval called prepupa can be harvested alone (self-harvesting) resulting in high added value, namely containing 40% protein and 30% fat which is used as feed for fish and livestock instead of fish meal(Cheng et al., 2017; Mutafela, 2015). The use of BSF as animal feed can cover the financing of waste management in low and middle countries (Diener, 2010)

One of the subdistricts in Bandung City with a maggot house is Mengger subdistrict, Bandung Kidul District. There is a 150 m^2 maggot house operated by four city government management officers. The Mengger sub-district has five hamlets (RW). Nevertheless, 1RW, which is RW 05, is a part of the Batununggal Indah housing complex, which has independently managed its waste. Thus, Rumah Maggot is only obliged to serve 4 RWs. The purpose of this study is to identify various problems that must be resolved first so that the circular economy concept can be implemented at the Mengger Maggot House. After knowing the various existing obstacles, various solutions were then created which were agreed upon and worked on together with all stakeholders in Mengger Sub-district.

Research Methodology

Research Location

The Mengger subdistrict area, hamlet (RW) boundaries and the location of the maggot house are shown in Fig 1.

Figure 1. Mengger Subdistrict and hamlet (RW) boundaries

This research was carried out in several activities, including:

1. Identify various problems with organic waste sorting and collection system

2. Identify the effectiveness of organic waste processing in the maggot house
3. Analyse the potential benefits of processing organic waste in maggot houses

Identify various problems with organic waste sorting and collection system

Collection of source-segregated organic waste is the beginning of successful waste management. The current Waste Management system must be transformed into form which allows recirculation of materials (i.e. reuse, remanufacturing, and recycling) by improving all stages of the Waste Management system. Waste treatment corresponds to the processing and transformation of waste to useful resources. This may be done in several ways, through material recovery, recycling, incineration with energy recovery, biogas production and composting. It is the treatment function of Waste Management that links back to material production, in a 'new' waste-to-resource stage (Rousta et al., 2017). This is also known as the concept of circular economy.

The method used to identify various problems in the sorting and collection system is:

1. Take an approach by participating in routine activities in the community, as well as socializing waste sorting at home.
2. Conduct a detailed survey by observing waste collection activities carried out by waste collection officers in each RT/RW

Identify the effectiveness of organic waste processing in the maggot house

The rate of waste consumption by BSF larvae varies according to the type of waste, moisture content, numbers of larvae, larval size and temperature (Alvarez, 2012; Rochaeni et al., 2021). And many factors influence the growth of maggots in degrading organic waste (Mulyatna et al., 2022). The method for identifying the effectiveness of organic waste processing by maggots in the Mengger maggot house is carried out by collecting data on incoming waste and maggot production within 1 month of August 2024. And observe all waste processing activities in the maggot house.

Analyse the potential benefits of processing organic waste in maggot houses

Maggots can be given as feed by mixing processed maggots or by giving fermented bran that has been supported by BSF maggots (Tani Link, 2022).

Poultry farmers usually use more than 1 type of feed, because currently there is no single type of feed that can meet the complete nutritional needs of poultry. Likewise, using BSF maggots as feed is usually only to replace one type of feed, for example, fish meal or bone meal (Tani Link, 2022).

In this study, simple research was carried out on the maggots produced by the Mengger Maggot House. Drying was carried out at 3 different temperature and time levels, namely drying at 60oC for 14 hours, drying at 105oC until constant weight, and drying at 170oC for 25 minutes. After drying, the fat and protein content was checked at the Unpas Food Technology Laboratory.

Result and Discussion

Identify waste sorting problems at source

Based on discussions with accompanying officers from the Bandung City Environmental Service, it was stated that each RW in Mengger Subdistrict has different community characteristics. Because of this, each RW has a unique method for sorting socialization. RW 01 is mostly a housing complex area and settlements in alleys. The approach and socialization is carried out using a door to door system. RW 02 is a community that lives in an organized housing complex, where there is already a Buruan Sae program. The approach was carried out through discussions with neighborhood (RT) head and Family Empowerment and Welfare (PKK) activist

women. RW 03 is mostly middle to lower class people, with fairly dense settlements. The approach and socialization is carried out by participating in morning exercises together. RW 04 is a medium density settlement. Based on discussions with the head of RW 04, the approach and socialization was carried out using a door to door system. No socialization and survey was carried out in RW 05 because the management of the Batununggal Indah complex had already carried it out and the waste had been processed in the compost house. Figure 2 to Figure 5 shows various socialization activities carried out in several RWs.

Figure 2. Socialization in RW 01

Figure 3. Put stickers on the house where waste is sorted.

Figure 4. Morning sports continued with sorting socialization in RW 03

Figure 5. Door to door socialization in RW 04

Several findings regarding Mengger Village residents' compliance with waste sorting were drawn as a result of the approach, observations, and interviews with various stakeholders. These conclusions include:

1. Residents have not consistently sorted waste for various reasons.
2. Some residents who already have kangEmpos buckets use them as organic waste buckets.
3. Organic waste in RW 03 is given to farms around the house.
4. Most residents want organic waste to be collected from every house by officers.

In general, only 30.2% of Bandung city residents have just started sorting, of which only 5.6% use organic waste in reduction activities and only 0.7% of respondents who have become waste bank customers, and only 0.7% of respondents who use kang pisman 17.9%. In the system for collecting, transporting and storing waste at temporary waste dump (TPS), there is no separation of organic and inorganic waste(Irmawartini et al., 2023). Based on data in the Bandung City Solid Waste Management Master Plan, which was prepared in 2023, it is stated that waste generation in the city of Bandung is 0.58 kg/person/day, with the composition showed in Table 1.

Table 1. Waste composition

No	Composition	Percentage
1	Food waste	24.03%
2	Compostable	20.87%
3	Recycle waste	37.87%
4	Specific waste	1.02%
5	Residue	20.21%

The specific gravity of mixed waste in Bandung City is 228.32 kg/m^3, with a special organic specific gravity of 241.11 kg/m^3 (Bandung City Environmental Service Office, 2023).

The total waste potential and organic waste potential can be computed using Mengger

Village population statistics, as indicated in Table 2.

Table 2. Number of resident and organic waste

No.	RW	RT	Number of Resident	Quantity of Waste (kg/day)	Quantity of organic waste (kg/day)
1	RW 01	RT 01	240	139.2	33.408
		RT 02	333	193.14	46.353
		RT 03	495	287.1	6.890
		RT 04	406	235.48	56.515
		RT 05	274	158.92	38.140
		RT 06	455	263.9	6.333
		Sum	**2,203**	**1,277.74**	**306.657**
2	RW 02	RT 01	233	135.14	32.433
		RT 02	381	220.98	53.035
		RT 03	567	328.86	78.926
		RT 04	107	62.06	14.894
		RT 05	252	146.16	35.078
		RT 06	144	83.52	20.044
		Sum	**1,684**	**976.72**	**234.412**
3	RW 03	RT 01	208	120.64	28.953
		RT 02	175	101.5	24.360
		RT 03	319	185.02	44.404
		RT 04	461	267.38	64.171
		Sum	**1,163**	**674.54**	**161.889**
4	RW 04	RT 01	549	318.42	76.420
		RT 02	440	255.2	6.124
		RT 03	210	121.8	2.923
		RT 04	110	63.8	1.531
		RT 05	478	277.24	66.537
		RT 06	240	139.2	3.340
		Sum	**2,027**	**1175.66**	**282.158**
5	RW 05	RT 01	674	390.92	93.820
		RT 02	932	540.56	129.734
		RT 03	1765	1023.7	24.568
		RT 04	144	83.52	20.044
		RT 05	546	316.68	76.003
		Sum	**4,061**	**2,355.38**	**565.291**
		Total	***11,138***	***6,460.04***	***1.550.409***

If the organic waste from RW03 is used as animal feed and the waste from RW 05 is managed independently, then the total organic waste that must be processed at the Mengger Maggot House is 823 kg/day.

Identify waste collection problems

A detailed survey of the waste collection system in all RT and RW in Mengger Subdistrict provided the following findings:

RW 01 waste collection system

1. There are 6 RTs with 5 collection officers.
2. There are 5 carts, 3 garbage motorbikes, and several trolleys.
3. Garbage motorbikes are used when collecting waste from RT 04 and RT 06 which have adequate road width.
4. Waste collection is carried out door to door and from communal points.
5. Trash trolleys are used on roads where carts cannot pass, the trash from the trolley is then transferred to the cart.
6. The collected waste is taken and further sorted at TPS RW 01.
7. Some of the organic waste was taken by Rumah Maggot officers and some was taken by Bandung City Waste Management along with residue

RW02 Waste Collection System:

1. There are 6 RTs, with 7 collection officers.
2. RT 02 and RT 03 are served by 3 officers who manage themselves, other RTs are managed by their respective RT Heads.
3. There is already a Buruan Sae Program which accepts some organic waste from residents.
4. The waste is taken to the TPS/compost house RW05.

RW 03 waste collection system:

1. There are 4 RTs with 2 collection officers
2. Priority for collection is inorganic and residual waste, if there is organic waste, it will be transported to the TPS.
3. Organic waste such as food waste (used rice, used wheat, corn, etc.), vegetables and leaves are mostly used by various livestock farms spread across RW 03.
4. The organic waste brought to Rumah Maggot is organic waste sorted by waste collectors at the TPS, the majority of which is fruit and vegetable peelings.

RW 04 waste collection system:

1. There are 6 RTs with 3 officers, plus 1 Maggot House officer.
2. 3 rubbish collectors in RW 04 pick up all kinds of rubbish, the majority of which is inorganic rubbish.
3. Maggot house officers who took part in

picking up trash took organic waste from all RTs in RW 04.
4. Waste collection at RT 01 and RT 02 is carried out door to door and from collection points.
5. RT 03, RT 04 and RT 06 waste collection is carried out from the collection point.
6. RT 05 Organic Waste has never been collected and deposited at the maggot house because in RT 05 there are apartments and the majority of houses are rented

Some waste collection activities are shown in Figure 6. Figure 7 show the several small farm in RW 03.

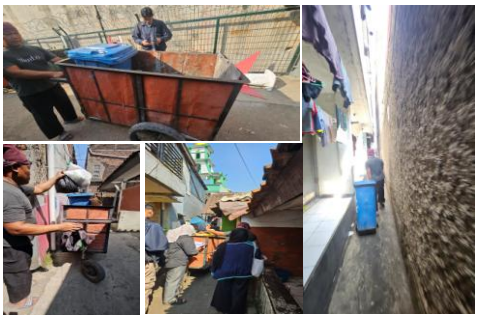

Figure 6. Waste Collection Activities

Figure 7. Several small farms in RW03

Several conclusions were drawn from in-depth observations and surveys of the Mengger Subdistrict's waste collecting system, including:

1. The collection system is already running in all RT/RW, although not all of them have implemented segregated waste collection.
2. Officers collect waste as it is from residents. If it has been sorted, it will be stored separately at the TPS or taken to the maggot house by Rumah Maggot officers. If it has not been sorted, officers will carry out sorting at the TPS to separate waste that can be sold.
3. There is no certainty about the transportation of waste from each RW to Rumah Maggot.

Waste Management systems can only recirculate the materials that they receive, making the collection and separation functions of Waste Management systems crucial for achieving high recirculation rates (Rousta et al., 2017).

Identify problems in the Mengger maggot house.
In August 2024, an extensive evaluation of the Mengger Maggot House's organic waste processing steps was conducted. Several findings were drawn about the issues at the Mengger Maggot House, including the following:

1. The amount of organic waste entering the maggot house is very low, still far from the target of 1 ton/day.
2. During August 2024, the amount of waste entering the maggot house is 2.07 tons/month or an average of 82.88 kg/day, showed in Table 3.
3. Most of the rubbish that enters the maggot house comes from RW 04 because the maggot house officers take it directly to the settlement in RW 04.
4. Organic waste from RW 01 was taken by maggot house officers from TPS RW 01.
5. If there is not enough organic waste to feed the maggots, the maggot house officers will take the organic waste from the RW 05 Compost House.
6. There are no maggot sales in August because maggot egg products are low. The number of fresh maggots sold during February-July was only 614 kg or an average of 102.3 kg/month, showed in Table 4.

Table 3. The amount of organic waste enters the maggot house on August 2024

Date	RW 01	RW 02	RW 03	RW 04	RW	05	Total
01/08/2024	48			19		98	165
02/08/2024	20			46		80	146
03/08/2024							0
05/08/2024	33			80			113
06/08/2024	30					570	600
07/08/2024	20			45			65
08/08/2024				43			43
09/08/2024				40			40
10/08/2024	42			32			74
12/08/2024				53			53
13/08/2024				21			21
14/08/2024	27			49			76
15/08/2024	23			24			47
16/08/2024				49			49
17/08/2024	37		21				58
18/08/2024				93			93
20/08/2024	18			22			40
21/08/2024	36			24			60
22/08/2024				23			23
23/08/2024	31			34			65
24/08/2024	10			36			46
26/08/2024	34						34
27/08/2024				25			25
28/08/2024	49			30			79
29/08/2024	30			27			57
Sum	**488**	**0**	**21**	**815**		**748**	**2072**
					Average		**82,88**

Tabel 4. Number of fresh maggots sold

Month	Maggot sold (kg)
February	93
March	135
April	205
May	78
June	20
July	83
Total	**614**
Average	**102.3**

Observing the physical conditions of processing, buildings and complete equipment in the maggot house resulted in the following conclusions:

1. The incoming organic waste is crushed manually, which takes quite a long time and results in uneven sizes.
2. There is no clean water flow to the Maggot House, so it is difficult for officers to clean the Maggot House.
3. There is no electricity, so there can be no lighting or electrical equipment.
4. There was a leak in the fly cage, so the birds came in and disturbed the flies.
5. There is not enough sunlight in the fly cage so the fly mating and egg-laying process is not optimal.
6. The slope of the biopond tub separating the prepupae is too steep.

Some of the physical conditions of the maggot house are shown in the following figure.

Figure 8. Some of the physical conditions of the maggot house (a). crushed manually, (b). dark maggot house, (c). leaking fly cage, (d). low sunlight, (e). slope biopond

Potential benefits of processing organic waste in maggot houses

Based on Eawag, 2017 stated that from 1 ton of converted organic waste, 170kg of fresh maggots or 45kg of dried maggots, and 400kg residue (kasgot) will be produced (Eawag, 2017). With the amount of organic waste processed as much as 823 kg/day, it is hoped that 140 kg of fresh maggots or 37 kg of dried maggots, and 329 kg of residue (kasgot) will be obtained. The current market price for maggots in Bandung City is IDR 4000-5000 per kg, so the potential daily income from selling fresh

maggots is IDR 280,000 per day. If sold in the form of dried maggots, the price is IDR 14,000 per 100g, then the potential income from selling dried maggots reaches IDR 5,180,000 per day, minus drying production costs which require electricity and fuel.

After conducting in-depth interviews with environmental service officers, maggot house officers, and potential customers, the following conclusions were made about the issue of selling maggots:

1. Maggot harvest time is uncertain because it really depends on the amount and type of organic waste as well as the quantity and quality of the maggots produced.
2. Buyers are not ready to buy maggots every time they are ready to harvest.
3. Some potential buyers require a large capacity of daily maggots, while maggot producers only produce maggots in a limited capacity.
4. Buyers have many sources of maggot production, so buyers can choose activists who are ready to sell when the buyer needs them.
5. The lifespan of a fresh maggot is only a few days, if it takes too long the maggot decreases in size and weight, and eventually turns into a pupa.

To extend the selling life of maggots and to increase the price of maggots, a maggot drying process is needed. The results of a simple study to see the water content, and fat and protein content in various drying variations were carried out, and the results are shown in Table 5.

Table 5. Water Content, Protein and Fat in various drying variations

No	Variation	Water content (%)	Protein (%)	Fat (%)
1	60^{o}C, 14 hours	37.9	20.26	7.25
2	105^{o}C, 2-3 hours	32.7	24.08	10.19
3	170^{o}C, 30 min	31	26.72	13.57

From table 5, it can be seen that increasing temperature does not have much effect on the water content of maggots, but the length of drying time has more influence on decreasing protein and fat levels. The longer the drying time, the lower the protein and fat content.

Many studies have been conducted on poultry feed derived from maggots. Some carry out variations in drying methods: spray-dried and oven-dried (Zulkifli et al., 2022) and in various temperature (Gadzama et al., 2023), as well as mixing with other materials to obtain the feed characteristics required by various regulations regarding poultry feed(Afnan et al., 2023). There is also research that focuses on the behavior of livestock after being fed maggots. Trials of giving maggots to free-range chickens did not show any rejection response. The test results also showed that chickens preferred fresh maggots to maggots in flour form(Natsir et al., 2020).

Advantages of BSF feed (Tani Link, 2022):

1. BSF has antimicrobial effects so it can be used as a substitute for AGP (antibiotic growth promoter).
2. Increase livestock's resistance to bacteria and fungi.
3. The protein content is quite high, namely around 40 - 50%, and the types of amino acids are quite complete.
4. The fatty acids in BSF maggots are medium chain, thus helping feed efficiency.

Disadvantages of BSF feed :

1. The fat content of maggots is relatively high (± 30%), even though fat is the limit for using raw materials in poultry feed. In several industries, BSF has processed maggots by pressing to reduce the fat.
2. Giving maggots in fresh form causes side effects for livestock.
3. The phosphorus content is lower than fish meal

Dried maggots from Menger Maggot House have a protein content below 30% and a fat content below 15%. Many national standards for protein content must be met by various animal feeds, such as:

1. SNI 8290.1.2016, SNI 8290.2.2016, SNI 8290.3.2016, SNI 8290.4.2016, SNI 8290.5.2016, SNI 8290.6.2016 regarding standard laying hens feed where crude protein content ranges from 15.50 % - 20%.
2. SNI 8173.1:2015, SNI 8173.2:2015, SNI 8173.3:2015 concerning standard broiler feed where the crude protein content ranges from 19 – 22%.
3. SNI 8512:2018 concerning chirping bird feed with a crude protein value of 8% - 14%.
4. SNI 01-7242-2006 regarding tilapia fish feed where the crude protein value is 25% - 30%
5. SNI 01-4087-2006 regarding catfish feed from seed to parent protein value 25% - 30%
6. SNI 01-4266-2006 concerning carp feed from nursery to brood stock protein value of 25% - 30%.

When compared with various SNIs and protein content, dried maggots from Mengger Maggot House are suitable for tilapia fish feed, catfish feed and goldfish feed from nursery to broodstock.

Recommendation

Recommendations for improving the performance of the Mengger Maggot House for implementing a circular economy are carried out by holding an FGD with all waste management stakeholders in Mengger Village, including the Village Head, sub-district staff, RW/RT heads, Maggot House officers, Gober (drainage channel cleaning) officers, PKK, and others. FGD activities are shown in Figure 9.

Figure 9. Focus Group Discussion with waste management stakeholders Mengger Subdistrict

The results of the FGD resulted in the following agreement:

1. It is necessary to increase compliance with sorting at the source, by involving PKK as cadres for socializing sorting in the RT/RW area.
2. Collection of organic waste at the RT/RW level is carried out by collection officers using a scheduled system.
3. The results of organic waste collection at the RT/RW level are collected at several collection points.
4. Transportation of organic waste from the collection point to the Maggot House is carried out by Gober officers on a scheduled basis.
5. The collection and transportation system and its scheduling need to be developed in more detail.
6. Various maggot processing equipment is needed in the form of maggot drying machines and flour-making and pellet-making machines.
7. Installation of State Electricity Company (PLN) electricity and connection of water supply from local water company (PDAM) to the maggot house

Conclusions

Improving performance at Rumah Maggot Mengger is one of the implementations of a circular economy where organic waste is processed into new raw materials or into new products that can be utilized in the production process. In this case, processing organic waste produces maggots whose product variations can be increased thereby increasing the selling price and extending their selling life. However, it is necessary to increase the amount of organic waste entering the maggot house first so that the number of maggots produced also increases. The increase in organic waste entering the maggot house is carried out by involving various stakeholders, such as PKK cadres as cadres for socialization of sorting in RT/RW areas, waste collection officers to collect waste in a segregated and scheduled manner from each RT and RW to the organic waste collection point, and Gober officer as officer transporting organic waste from the organic collection point to the maggot house according to schedule. To support all this, it is necessary to install PLN electricity and PDAM water supply, accompanied by complete maggot processing equipment.

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