

# Optimization of organic waste processing using Black Soldier Fly larvae Case study: Diponegoro university

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# Optimization of organic waste processing using Black Soldier Fly larvae

## Case study: Diponegoro university

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**Abstract.** Waste that is not handled correctly can cause problems for humans and the environment. Therefore, proper waste management efforts are needed to solve this waste problem. One method of processing organic waste is the use of Black Soldier Fly (BSF) larvae. Larvae BSF can degrade organic waste, and the life cycle of BSF acts as a decomposer. This study examines BSF larvae's ability to decompose biodegradable organic waste, especially for banana waste, cucumber waste, and food waste in the Diponegoro University environment, and to decide the effect of the variable type of food. The frequency of feeding carried out on the growth rate of BSF larvae and to choose the decomposition results of biodegradable organic waste carried out by BSF larvae. This research method is carried out by comparing the effectiveness of waste degradation by BFS with EM4. The value of significance in degrading waste is obtained from the calculation of the Waste Reduction Index, or it can be called WRI. The analysis results show that the WRI value in waste processing using BFS is more significant than in waste processing using EM4. That concludes that BSF fly larvae (*Hermetia illucens*) effectively reduce organic waste compared to EM4.

### 1. Introduction

Due to the increasing construction of construction facilities and the growth of campus residents at Diponegoro University, the greater the responsibility and challenges to deal with various waste problems. The waste problem is one of the problems, both in developed and developing countries, especially organic waste, which has not been resolved. The processed organic waste includes food residues and unwanted by-products from various industries, such as sewage sludge from sewage treatment plants, animal manure from livestock, and tofu residue from the manufacturing process of tofu. In large cities, the average solid waste generated is 2.01 billion tons/year. According to researchers, by 2050, landfills will reach 3.4 billion tons/year [1]. A large amount of organic waste will emit 1.6 billion metric tons of carbon dioxide, which will cause damage to the environment, which will increase to 2.6 billion metric tons by 2050 [1]. Improper organic waste management can also lead to many environmental threats and economic difficulties, such as increased flood risk and adverse effects on groundwater [2]. One of waste management is recycling. A more ecological and circular economy requires the recycling of organic waste [3]. Therefore, it is necessary to reduce waste appropriately to manage large amounts of organic waste safely and sustainably. In this case, insect larvae that reduce organic waste have proven to be effective and environmentally friendly because the larvae can ingest



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organic waste and convert it into larval biomass through the assimilation process without harming humans and the surrounding environment. The black army fly or *Hermetia illucens* is considered an ideal insect species because its larvae (BSFL) can biotransform various decay, survive under various environmental conditions, inhibit the growth of harmful microorganisms, and most importantly, adult Flies are not pests [4]. Another study found that BSF larvae can reduce the total waste by 50-80% (wet) [5].

The waste generated at Diponegoro University can be very diverse, one of which is organic waste produced from leftovers from food or snacks for students or leftovers from the canteen. In addition, there is also leaf litter scattered because of the many trees at Diponegoro University. However, most public considers organic waste processing as food waste with no economic value [3]. That is because the manager only sees in terms of the benefits derived from organic waste management. One concrete example is composting, which is not competitive with chemical fertilizers, which results in a low selling price of organic compost. In the end, the organic waste will be transported and stockpiled in the landfill [3].

This research will be carried out by using BSF larvae to degrade organic waste as food ingredients. Organic waste used as a sample was waste from student food scraps, leftovers from cooking or food in the canteen, and leaf waste. The final result of the research is to determine the percentage of organic waste reduction at Diponegoro University, which can be done through the use of BSF larvae.

## 2. Methodology

### 2.1. Material preparation

Preparation of the study was made by preparing tools and materials that will be used for experiments. The tools used are:

- Twelve containers, this is a plastic container used for composting.
- The analytical balance is used to measure the mass of organic waste and BSF. This working starts when the object is placed on the disk, where the object's mass will be distributed evenly throughout the area of the weighing disk.
- PH meter used to measure the PH in containers. PH meters measure the voltage between two electrodes and display the result converted into the corresponding pH value.
- A moisture analyser was used to measure the water content. The moisture analyser works with the LOD (Lost of Drying) measurement principle. The LOD will calculate the water and any other solvents lost in the heating process.

The materials used in this study are:

- Organic waste consists of fruit waste, vegetable waste, food waste, and new leaf waste. Each mass is 500 grams.
- maggot/BSF larvae as composting media, EM4 as a fermenter
- EM4 as a fermenter.

### 2.2. Experimental procedures

The research was conducted as follows:

- Divide organic waste into three parts for each type of waste to be put into containers so that it becomes 12
- Each container has a mass of 500 grams. Each type of waste is assigned a number 1, 2, and 3.
- Add maggot to containers 1 and 2, and add EM4 to containers.
- On the first day, measuring the mass, water content, and pH of the waste in each container.
- Day 2 to day 12, measuring the mass of maggot and pH in containers 1 and 2 and PH in container 3.

- On the 12th day, we measure the mass of waste, water content, and PH in each container and the mass of magot in each container.
- Make a record of the data obtained for analysis.

### 2.3. Data analysis

The data analysis is the waste weight that is important because it can determine the larvae waste reduction index. The total feed reduction is calculated first to calculate the waste reduction index, with the equation proposed by [6] as follows:

$$D = \frac{W - R}{W} \quad (2.1)$$

D = total feed reduction (mg)

W = total amount of feed provided (mg)

R = remaining substrate (mg)

Furthermore, to calculate the waste reduction index used the formula:

$$WRI = \frac{D}{t} \times 100 \quad (2.2)$$

D = total feed reduction (mg)

WRI = Waste Reduction Index

t = days of trial (day)

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## 3. Results and discussion

### 3.1. pH

Based on the results, it was found that the pH of the waste during the study follows:

**Tabel 1.** pH of organic waste.

Day	Fruit Peel Waste			Food Waste			Vegetable Waste			Leaf Waste		
	BSF 1	BSF 2	EM4	BSF 1	BSF 2	EM4	BSF 1	BSF 2	EM4	BSF 1	BSF 2	EM4
1.	4.03	4.01	4.04	4.49	4.46	4.03	4.89	5.79	6.64	8.72	8.5	7.88
2.	4.038	4.07	4.69	4.64	4.5	4.43	8.69	8.39	7.95	8.15	8.32	8.15
3.	4.2	4.08	4.61	4.45	4.5	5.02	8.0	7.99	8.11	8.22	8.35	8.03
4.	4.13	4.06	4.65	4.55	4.4	4.94	8.3	8.12	8.1	8.23	8.21	8.08
5.	4.038	4.07	4.69	4.64	4.5	4.43	8.69	8.39	7.95	8.15	8.32	8.15
6.	4.53	4.88	5.29	4.54	4.64	4.65	7.92	8	8.59	8.72	8	8.58
7.	6.65	6.83	6.34	5.93	4.69	6.10	8.80	8.77	8.93	9.04	8.82	9.1
8.	7.43	7.17	6.94	5.06	5.7	5.98	9.02	8.92	9.02	8.94	8.82	9.04
9.	7.42	7.55	6.46	5.27	6.68	5.82	9.18	8.98	8.89	9.06	9.10	9.10
10.	7.10	7.40	6.36	5.55	6.83	5.04	9.23	9.13	8.96	9.03	9.26	9.26
11.	6.86	7.20	6.53	6.10	6.94	4.57	9.24	9.30	9.15	9.13	9.14	9.14
12.	6.76	7.30	6.59	6.21	7.05	4.67	9.32	9.23	9.1	9.21	9.2	9.2

The result shows that the pH of all kinds of waste has a volatile trend where it was in the pH range of 4.01 – 7.55 for the fruit peel waste; 4.4 – 7.05 for the food waste; 4.89 – 9.32 for the vegetable waste; 8 – 9.26 for the leaf waste. In general, the BSF's pH from all kinds of waste has a similar pH range trend with the EM4. This result is also confirming previous studies that showed BSF larvae are competent in opposing and manipulating acidic (pH = 4.0) and primary (pH = 9.5) environments [7].

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### 3.2. Water content

It was found that the water content of the waste during the study was as follows:

**Tabel 2.** The initial water content of the waste.

	Kind of waste				
	Larvae	Fruit Peel	Food	Vegetable	Leaf
BSF 1 (initially)	88.24%	77.07%	94.03%	45.44%	
BSF 1 (final)	81.97%	87.29%	96.2%	22.39%	
BSF 2 (initially)	86.12%	80.17%	93.71%	41.45%	
BSF 2 (final)	92.55%	89.14%	99.98%	74.61%	

The optimum water content in BSF larval food is between 60-90% [8]. The result shows that the fruit peel waste and the food waste are still in the positive range of water content, yet the vegetable waste exceeds, and the leaf waste is below the optimum range. The survival rate of larvae decreases with the increase of water content. When the survival rate is high, the weight of the larvae decreases with the increase of water content. When the survival rate decreases, the survival rate increases [9].

The increase in water content indicates a process of waste decomposition. Increasing the water content in the waste can make it difficult for BSF larvae to reduce waste and cause the death of BSF larvae. If the water content is too high, it will also make it difficult to separate the residue from the insect biomass, so it is considered necessary to adjust the water content of the waste before using BSF to treat the waste [10]. The high microbial activity in the matrix with low matrix moisture content may be related to the high porosity and favourable oxygen transfer rate [11]. The high-water content and poor substrate structure may also cause problems for the late larvae as the larvae grow and develop through instar, their weight.

### 3.3. Larva weight

Sections It was found that the BSF larvae weight during the study was as follow:

**Tabel 3.** Larvae weight.

Day-	Kind of waste							
	Fruit Peel		Food		Vegetable		Leaf	
	BSF 1	BSF 2	BSF 1	BSF 2	BSF 1	BSF 2	BSF 1	BSF 2
1	0.1338	0.2480	0.1183	0.1390	0.1203	0.1569	0.1236	0.0643
2	0.1440	0.0986	0.1429	0.2179	0.0693	0.1080	0.0927	0.1407
3	0.1734	0.0943	0.1234	0.1839	0.0936	0.1134	0.1432	0.1312
4	0.0967	0.1003	0.1421	0.1242	0.1014	0.1321	0.1474	0.1131
5	0.0982	0.1014	0.1598	0.1609	0.1316	0.2138	0.1773	0.1162
6	0.1393	0.9892	0.1482	0.1098	0.1294	0.1455	0.1648	0.1532
7	0.1825	0.1632	0.1558	0.1928	0.1585	0.1585	0.1528	0.1623
8	0.1803	0.1825	0.2134	0.2279	0.2044	0.3130	0.1316	0.0372
9	0.1892	0.1343	0.3390	0.2190	0.2135	0.1485	0.1310	0.1019
10	0.1827	0.1750	0.2473	0.1971	0.1685	0.1651	0.1320	0.9900
11	0.1573	0.3829	0.3187	0.2807	0.2370	0.1400	0.1277	0.1651
12	0.1487	0.1912	0.1302	0.1407	0.1528	0.1070	0.1302	0.1332

The result shows that the weight of the BSF larvae, both BSF 1 and BSF 2, has a volatile weight development with a trend of increasing from the initial weight to the final weight except for the BSF 2 of the fruit peel waste and the BSF 2 of the vegetable waste.

### 3.4. Room humidity

During the research, the humidity of the room where the study was conducted was as follows:

**Tabel 4.** Room humidity.

<b>Day-</b>	<b>Humidity</b>
<b>1</b>	55.5
<b>2</b>	53.2
<b>3</b>	72.3
<b>4</b>	80.0
<b>5</b>	90.4
<b>6</b>	93.3
<b>7</b>	70.1
<b>8</b>	72.0
<b>9</b>	66.2
<b>10</b>	72.1
<b>11</b>	82.1

From these results, it can be seen that the initial humidity of the room is 55.5% which then decreases on the 2<sup>nd</sup> day. From the 3<sup>rd</sup> to the 6<sup>th</sup> day, the humidity rose to 93.3%. Then from day 7 to day 12, the humidity fluctuated until the absolute humidity of the room was 80.7%. Room humidity affects the survival rate of larvae, where the optimal humidity for larval growth is 70%.

### 3.5. Room temperature

During the study, the room temperature where the research took place was measured with the following results.

**Tabel 5.** Room temperature.

<b>Day-</b>	<b>Temperature (°C)</b>
<b>1</b>	28.5
<b>2</b>	29.7
<b>3</b>	28.1
<b>4</b>	27.4
<b>5</b>	26.3
<b>6</b>	24.4
<b>7</b>	29.4
<b>8</b>	27.7
<b>9</b>	28.6
<b>10</b>	27.6
<b>11</b>	27.5
<b>12</b>	27.8

From the results obtained, it is known that the room temperature on day 1 is 28.5°C. The room temperature fluctuated, with the lowest temperature being 24.4°C and the highest temperature reaching 29.4°C. The room temperature on the last day was 27.8°C. The average room temperature for 12 days was 27.7°C. This temperature is still in the optimum temperature range for the growth of BSF larvae. The BSFL is the warm temperature species. The best suitable temperature condition is between 25°C to 35°C. The temperature should not exceed 40°C because chances of surviving are reduced and inactivity induced when the temperature goes below 10°C[8].

### 3.6. Waste reduction index

Waste Reduction Index (WRI) at the final of the experiment is as follows:



**Tabel 6.** Waste reduction.

Container	WRI (%/day)			
	Fruit Peel	Food	Vegetable	Leaf
BSF 1	4.36	2.5	1.75	2.03
BSF 2	4.2	2.3	1.53	1.88
EM4	3.1	1.5	2.03	1.16

The higher the WRI value, the more waste consumed. The result shows that the waste processing with BSF larvae is more effective in reducing waste for fruit peel waste, food waste, and leaf waste as the WRI value is higher in BSF larvae than the WRI value of EM4. For the vegetable waste, the WRI value of the EM4 container has a higher WRI value than in the BSF container. The most effective waste reduction is in the BSF 1 container for the fruit peel waste as it has 4.36% waste reduction per day.

#### 4. Conclusion

Footnotes Organic waste management at Diponegoro University can be further optimized by processing organic waste using BSF larvae to reduce the amount of waste of Diponegoro University.

The ability to reduce organic waste by BSF larvae is more effective than EM4 that showed with Waste Reduction Index. For fruit peel waste, the WRI for BSF is 4.36 and 4.2%/day; meanwhile, EM4 is 3.2%/day. WRI for food waste is 2.5 and 2.3%/day for BSF and 1.5%/day for EM4. The WRI of BSF for vegetable waste is 1.75 and 1.53%/day, and WRI for EM4 is 2.03%/day. Furthermore, lastly, WRI for leaf waste are 2.03 and 1.88%/day for BSF and 1.16%/day for EM4. Therefore, it can be concluded that BSF can reduce organic waste better than EM4.

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