Eudrilus Eugeniae And Lumbricus Rubellus Density Effect In Agriculture Waste Treatment

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Abstract— Solid waste as the organic and inorganic waste materials from sources have become the real issue in big cities or villages including agricultural waste. This study aims to determine the effect of organic waste characteristics and worm density in the vermicomposting process. To achieve these objectives an analysis of chemical and physical parameters is carried out. The method of this research are using two type of earthworm that is *Eudrilus eugeniae (EE)*, *Lumbricus rubellus (LR)* to be varied in several composition of cassava peels, vegetable waste and cow manure. The variations consist of 1.5kg/m^2, 2kg/m^2, and 2.5kg/m^2 for both type of earthworm. Parameters to be measured are chemical (pH, temperature and humidity) and physical (waste weight). All physical and chemical parameters are still in the range determined by experts, the pH parameters are in the range 7-8, the temperature parameter is in the range of 21-29°C, and the humidity parameter is in the range of 36-71%. In this study, environmental conditions greatly affect the vermicomposting process, namely the pH value of 7.00-8.00 and the temperature of 26.5-28^{O}C is still in ideal conditions for worm life, while the humidity of 60% -80% does not meet the ideal conditions for worms because it is too moist caused by raw materials used are green vegetables that have high water content. Density variations in each waste variation affect the amount of waste reduction both in EE and LR media. The highest waste reduction for 1.5 kg/m^2 of *Eudrilus eugeniae* in M4D1 variation (30% cow manure and 70% cassava peels) by 56% waste reduction. Meanwhile for 2.5 kg/m^2 *Lumbricus rubellus* in the D3M4 and D4M4 variation (50% cow manure and 50% vegetables; 30% cow manure 70% of vegetables) can reduce by 63%.

Index Terms—*Eudrilus eugeniae*, *Lumbricus rubellus,* cassava peels, vegetable waste, cow manure, waste reduction

1 INTRODUCTION

Solid waste as the organic and inorganic waste materials from sources have become the real issue in big cities or villages [1]. Likewise, in most common agriculture waste is major problem, one of them is chayote and cassava peel. Both of agriculture waste dominated in several villages due to the high interest of residents. Chayote and cassava are easy to plant and long to harvest life causes a large amount of residual leaf waste that has not been utilized properly. The waste was degraded naturally until there is further land management. Besides disrupting aesthetics, the waste is generally discharged into water bodies. Besides the problem of agricultural and plantation industry waste, cow manure is also a problem that needs attention. Based on data from the Department of Animal Husbandry and Fisheries (Disnakan) of Bandung Regency in 2011 [2], the population of dairy cattle in Kab. Bandung currently reaches around 27,000. One of the most widely used treatments is to make compost products. Foliage wastes especially dried conjoined leaf squash can also be used as compost material because it is easy to find and a faster decomposition process. Composting using vegetable waste can reduce the impact of environmental changes by 40% to 70% compared to landfill and burning [3]. Previous research showed that reducing solid waste problem can be very effective, beneficial and profitable by by using earthworms to be convert it into compost [4]. This study aims to determine the effect of organic waste characteristics and worm density in the vermicomposting process. In this research, organic fertilizer from cow manure and agriculture waste will be conducted using vermicomposting method using *Eudrilus eugeniae* and *Lumbricus rubellus* worms. It is hoped that with this method agricultural waste and cow manure can be reduced. Both earthworm conducted in the same condition and the reduction of waste variation will be measure to be showed the highest waste reduction.

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2 RESEARCH METHODOLOGY

2.1 Materials

Several equipment that used in this study are:

Table 1. Equipments

No.	Material	Specification	Number
1.	Box	0,5 x 0,5 x 0,2 m	2x32 =64
2.	Sack	-	2x32=64
3.	Buckle	-	1x2=2
4.	pH meter	-	1
5.	Termometer	NSI-224	1
6.	Soil Hygrometer	-	1
7.	Analytical balance	SF-400	1

Several materials that used in this study are:

Table 2. Materials

No.	Material	Unit
1.	Cow manure	32 kg
2.	Fermented cassava peel	20 kg
3.	Chopped vegetable waste	544 kg
4.	Bio-activator (EM4)	1000 ml
5.	Brown sugar	1 kg
6.	Water	Secukupnya
7.	*Eudrilus eugeniae*	15 kg
8.	*Lumbricus rubellus*	15 kg

In this study, parameters are studied and measured physical and chemical parameters. Chemical parameters that measured are media acidity (pH), temperature media, and humidity media.

Table 3. Chemical Parameter

No.	Parameter	Unit	Method
1.	pH	-	pH meter
2.	Temperature	^oC	termometer
3.	Humidity	%	*moist detector*

Meanwhile, the modified physical parameters consist of changes in the changes in weight in the media.

2.2 Research Design

The design of this study uses a pilot scale. The fermentation process lasts for 7 days and the composting process lasts for 30 days. At the bottom of the box is given a worm house or bedding using silage leftover from animal feed. In this study, using 2 types of worm with each of 4 variations in material composition and 3 variations in density with repetition. The reseach design can be seen in table 4.

Table 4. Research Design of *Eudrilus eugeniae (EE)* and *Lumbricus rubellus (LR)*

Design Code		Density (kg/m^2)	Waste Precentage (%)
EE	LR		
M1D0	D0M1	-	100%CM
M2D0	D0M2		100%CP/VW
M3D0	D0M3		50%CM 50%CP/VW
M4D0	D0M4		30%CM 70%CP/VW
M1D1	D1M1	1.5	100%CM
M2D1	D1M2		100%CP/VW
M3D1	D1M3		50%CM 50%CP/VW
M4D1	D1M4		30%CM 70%CP/VW
M1D2	D2M1	2	100%CM
M2D2	D2M2		100%CP/VW
M3D2	D2M3		50%CM 50%CP/VW
M4D2	D2M4		30%CM 70%CP/VW
M1D3	D3M1	2.5	100%CM
M2D3	D3M2		100%CP/VW
M3D3	D3M3		50%CM 50%CP/VW
M4D3	D3M4		30%CM 70%CP/VW

*CM = Cow manure, CP = Cassava Peels and VW = Vegetable Waste

3 RESULTS AND DISCUSSIONS

3.1 Initial Characteristics

Several factors that affect to quality of product are chemical composition, physical, chemical and structural characteristics contained in raw material [5]. In the table 5 below, we can see each characteristic of wastes composition.

Table 5. Humidity of Vegetable Wastes Composition

Composition	Humidity (%)
Cow Manure	19,5
Solid Waste	53,85
Cow Manure 50% **Vegetable Waste** 50%	36,67
Cow Manure 30% **Vegetable Waste** 70%	43,54

The best raw material for the composting process is wet organic waste such as fruit and vegetable waste, besides being easily decomposed, vegetable waste has a good nutrient content in plant growth [6]. Vegetable waste used in the vermicomposting process has several advantages and disadvantages. The advantage gained is a lot of quantity and easily obtained, but the disadvantage is the quality of raw materials that vary [7].

Table 6. Humidity of Cassava Peels Wastes Composition

Composition	Humidity (%)
Cow Manure	19,5
Solid Waste	13
Cassava Peels 50% **Vegetable Waste** 50%	16,25
Cow Manure 30% **Cassava Peels** 70%	14,95

The treatment of cassava peel includes putting it directly into the soil, for animal feed, burning or processing it into a more stable organic fertilizer called compost [8]. In average, cassava peels are less humid than vegetable waste almost half than those one.

3.2 Initial Fermentation

Microorganisms in the fermentation process mostly use simple compounds as their food source, such as sugars, starches, and proteins, and generally do not use complex compounds such as cellulose or lignin. The fermentation process is very important because it can prevent worm deaths caused by toxic substances such as pathogens, salt and ammonia contained in animal waste [9]. In the fermentation process, temperature measurements are carried out for 7 (seven) days which can be seen in Figure 1.Temperature measurements in the fermentation process showed that a significant rose occurred on the 3rd day and the dropped on rest days. Cassava skin waste has a higher temperature compared to cow manure and vegetable waste was the lowest one. The highest temperature in cow manure was 46.5 °C while the highest temperature in cassava skin waste and vegetable waste were 46.8 °C and 44.8 °C.

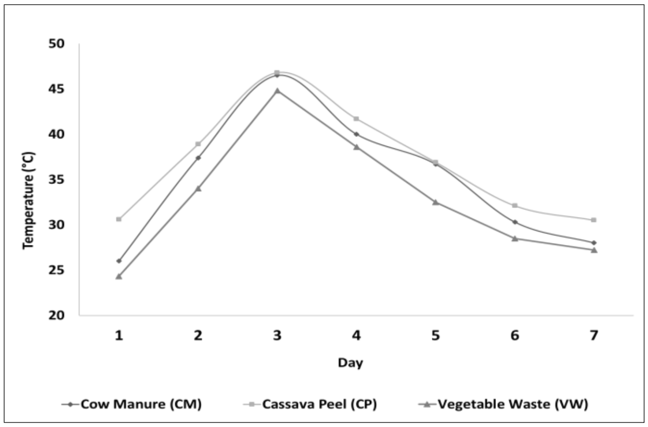


Fig 1. Initial Fermentation for Temperature

Other research [10] found that in 7 days of fermentation, more than 95% of fecal coliforms and Escherichia coli were reduced. They also found that with increasing fermentation time, the biomass of carbon microorganisms and dissolved organic carbon from the waste mixture decreased. They concluded that the 7-day fermentation period is ideal for vermicomposting of a mixture of paper and cow manure waste.

3.3 Chemical Characteristics

3.3.1 pH

The results of the analysis of pH on organic agriculture were 6.9 and on inorganic agriculture were 6.7 while the optimum pH of earthworm life was at neutral pH [11]. PH measurements carried out every day for 30 days can be seen in Figure 2.

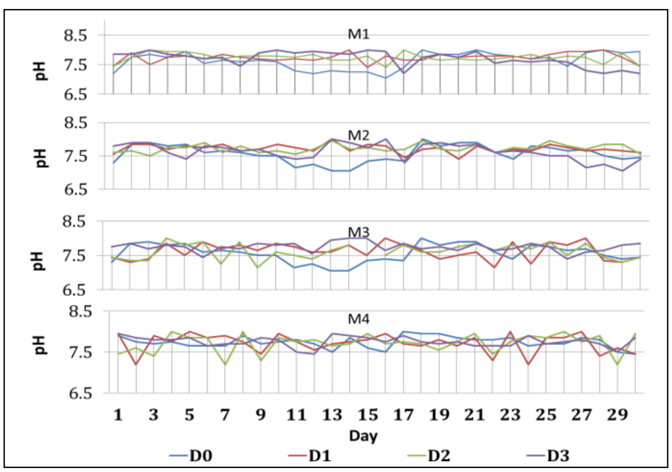
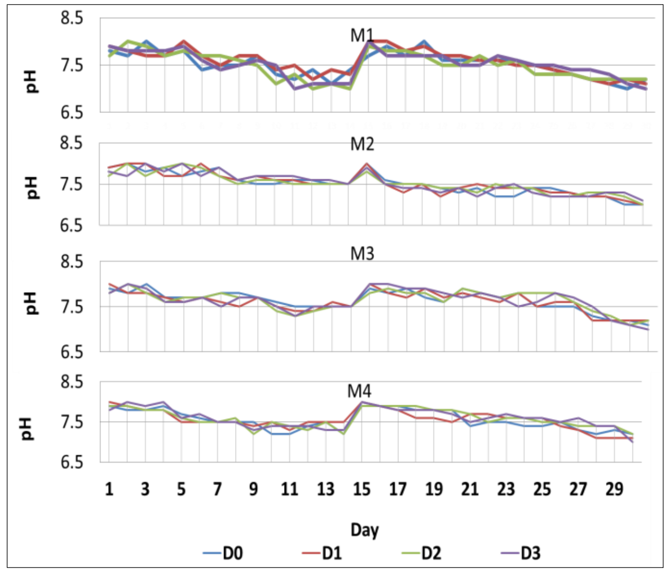


Fig 2. pH in *Eudrilus eugeniae (EE)* Media

The ideal pH for earthworm living places is between 6.5 -7.2 [12]. Earthworms are very sensitive to the acidity (pH) of the soil. Soils with acidic pH can disturb the reproductive power and growth of earthworms, because the availability of nutrients is relatively limited. In this figure 2 showed that pH was fluctuated and the average pH range was around 7-8. Yet, the worm growth continued to be normal. So EE are only sensitive to acidic media, but their growth does not affect the state of the alkaline media.The pattern in each variation were same, the decrease in pH at the beginning of (day 1 to 4) with a pH range of 7.80-8.00 and fluctuated again until the day 14 in the pH range of 7.20- 7.50. Then the pH rose in the range of 7.80-8.00, and fluctuated in the pH range of 7.40-7.80 and neutral pH until the day 30 day when the shrinkage process by microorganisms and worms has been completed [13]. PH changes is the initial phase of composting, a decrease in pH due to the rapid growth of microbes that form organic acids. The pH value will then increase gradually due to the increase in NH_3 produced by biochemical reactions originating from materials containing high N. Theoretically; products that have been through the composting process will have a neutral pH in



the final phase of composting.

Fig 3. pH in *Lumbricus rubellus (LR)* Media

3.3.2 Temperature

The optimal temperature of earthworm media for growth is 25-28°C. Temperature measurements in each media have increased and decreased fluctuatively. The higher the temperature the more worms consume oxygen. Thus, the decomposition process will run faster [14].

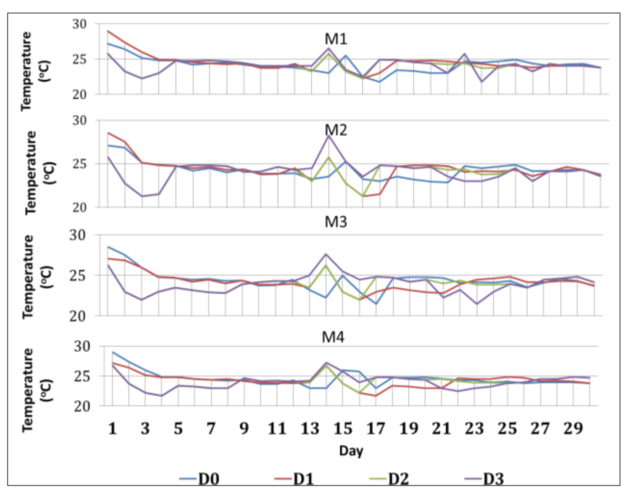


Fig 4. Temperature in *Eudrilus eugeniae (EE)* Media

From figure 4 showed all variations have similar pattern that the temperature rise occurred on the 13th day reaching the peak on the 15th day with a temperature of 24-26.5 °C and stable again after the 19th day. While from figure 5, we can see that the temperature are more fluctuative, decreased media temperature occurred in days 1 to day 4 by 27-28.3°C, then continue decreases by day 9 to 26-27°C. On the 10th day to the 14th day the temperature gradually decreases with 25.8°C. On 16th to 30th day, temperature drop gradually and reach a stable temperature in the range of numbers 26.8-26.3°C then the compost temperature rises at 27.8°C.

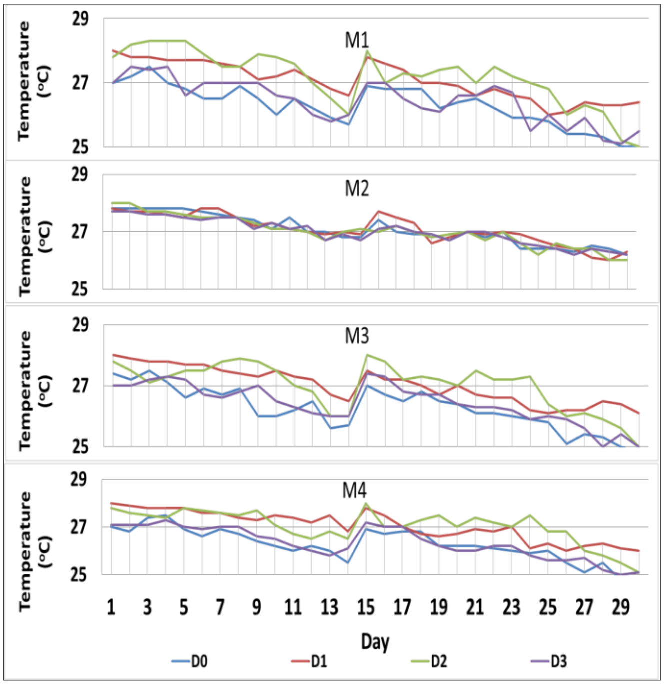


Fig 5. Temperature in *Lumbricus rubellus (LR)* Media

In line with the research [15] that the optimum temperature for earthworm growth ranges between 15-25°C, but temperatures slightly above 25°C can still be tolerated for earthworm growth with condition pH and humidity in accordance with the standards. So when the temperature is high, the media must be stirred immediately so that the temperature is evenly distributed. The temperature of the media can also be influenced by the environment. When measurements are taken in the morning or when it is raining then the temperature of the media is also low. When measurements are taken during the day and in the dry season the temperature of the media will also be high.

3.3.3 Humidity

Worm growth is influenced by humidity parameters that determine optimum conditions of a medium for worm habitat. Humidity measurements carried out every day for 30 days can be seen in Figure 6.

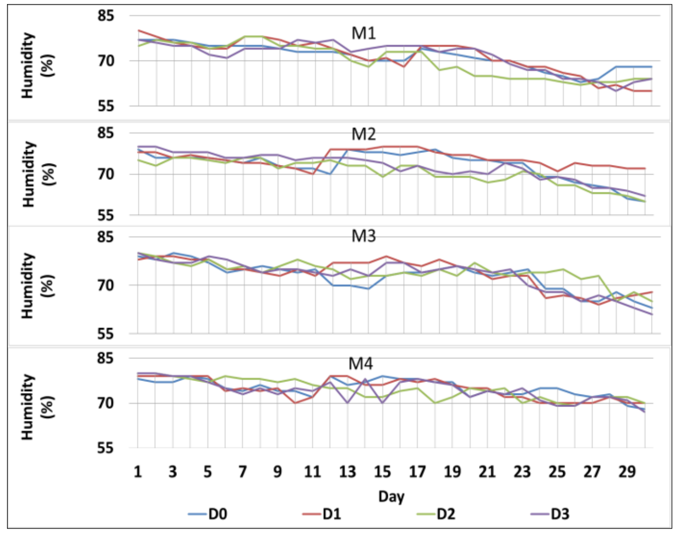


Fig 6. Humidity in *Eudrilus eugeniae (EE)* Media

Based on the humidity measurements showed the average media humidity was 36-71%. This research is still in accordance with the criteria for the earthworm's place of life stated by [15] that the optimum humidity for earthworms is 42-60%. Slightly more or less lack of moisture value does not affect the activity of earthworm growth. Soil moisture plays an important role in supplying oxygen in the vermicomposting process. Humidity greatly influences the activity of microorganisms and earthworms. Proper humidity will make the process of waste degradation take place optimally.Compare to humidity in EE, LR humidity media are more humid than those in ER media (figure 7). The research [16] believes that the optimal humidity in the vermicomposting process is 40% -60%. Humidity below 40% will result in decreased microorganism activity and if humidity is greater than 60% then the air volume will decrease and anaerobic fermentation will occur which can cause unpleasant odors. In this study, moisture fluctuations occurred in each material in the range of 60-80%, the condition was not included in the optimal humidity range for the growth of worms that is 60-70% because the vegetable material used has a fairly high water content.

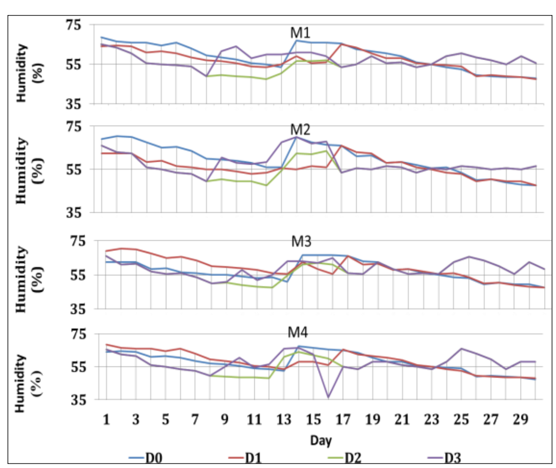


Fig 7. Humidity in *Lumbricus rubellus (LR)* Media

3.4 Physical Characteristics

Earthworms use various organic materials as energy sources. Even in poor conditions, food extracts can be obtained from the soil to survive. The growth of earthworm populations causes a reduction in the weight of the substrate used for making vermicompost through bio-oxidation and stabilization of organic matter through interactions between earthworms and microorganisms [17]. Although the main benefits of microorganisms are responsible for the biochemical degradation of organic matter, earthworms play an important role in the process by breaking down the substrate, increasing the surface area for the growth of microorganisms, and changing their biological activity [18].

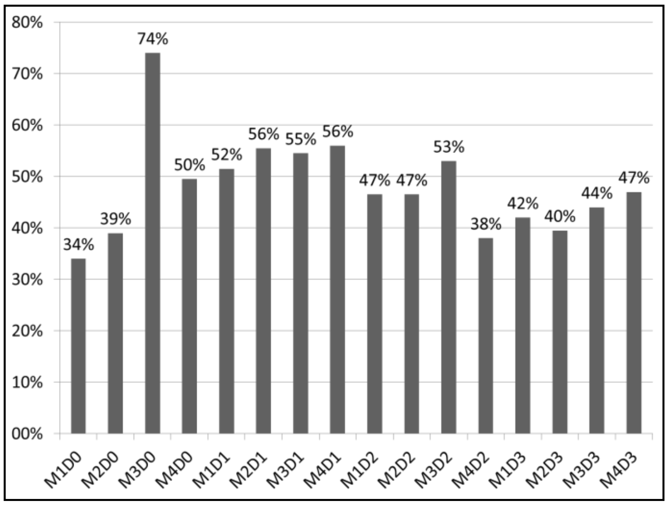


Fig 8. Weight Reduction in *Eudrilus eugeniae (EE)* Media

The highest bioconversion of organic waste was found in M1D4 treatment by 56% with a medium consisting of 30% cow manure and 70% cassava peel waste and a density of 1.5 kg/ m^2 as seen in figure 8. While the lowest bioconversion was found in M4D2 treatment by 38% with a medium consisting of 30% cow manure and 70% cassava peel waste and a density of 2 kg/ m^2.

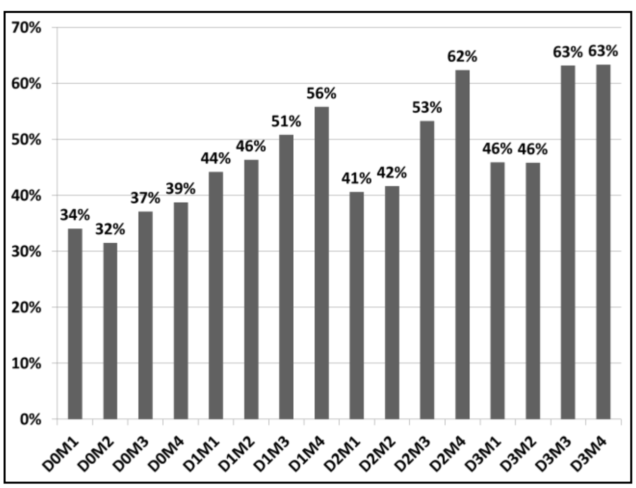


Fig 9. Weight Reduction in *Lumbricus rubellus (LR)* Media

Figure 9 showed density variations in each waste variation affect the amount of waste reduction. The highest reduction of waste was found in the D3M3 and D3M4 variations of 63%. In the variation of D0, the highest reduction of waste by the variation of M4 material by 39%, this can occur because based on observations of pH, temperature and humidity shows the ideal value for microorganisms. The highest reduction of waste in variation D1 was found in variations of vegetable M4 material by 56%. In the variation of material D2 can reduce waste by 62% in the M4 variation.Previous research [19] said that in conditions of low population density, an increase in earthworms would be good but the process of reduction of waste would be slow. Earthworms will stop eating when full and no matter how much food is still available. On the other hand, if the population density is too high, the process of waste reduction will proceed very quickly at first, and will slow down in a very short time. Earthworms will suffer from limited food and their growth will be hampered, this condition will reduce the earthworm biomass.In this study the D1 variation showed the highest worm biomass, while the D3 variation showed the greatest reduction, besides that the Lumbricus rubellus worm could degrade wastes up to 63% and M4 (a variation of 30% cow dung and 70% vegetables), the average yield of reduction showed high results that is equal to 55%. This research is different from the research conducted by others [19], namely the density of the Lumbricus rubellus worm of 2.5 kg/m^2 produces the highest worm biomass but at the same time provides the lowest amount of organic fertilizer.

4 CONCLUSION

Variation in the composition of organic waste in general does not have a different effect on environmental conditions in the vermicomposting process. Value of pH 7.00-8.00 and temperature 26.5-28^{o}C are still in ideal conditions for worm life, while the composition of organic waste with a high percentage of green vegetables does not meet ideal conditions in the vermicomposting process. This is because green vegetables have high water content, so that environmental conditions become too moist.Density variations in each waste variation affect the amount of waste reduction both in *Eudrilus eugeniae* and *Lumbricus rubellus* media. Within 30 days, the highest waste reduction for 1.5 kg/m^2 of Eudrilus eugeniae in M1D4 variation (30% cow manure and 70% cassava peels) by 56% waste reduction. It means, the ideal density for EE is 1,5 kg/m^2 in this variation.Meanwhile for 2.5 kg/m^2 Lumbricus rubellus in the D3M3 and D3M4 variation (50% cow manure and 50% vegetables; 30% cow manure 70% of vegetables) can reduce by 63%. That means, the ideal density for LR is 2,5 kg/m^2 in this variation.

ACKNOWLEDGMENT

The author would like to thank the Department of Environmental Engineering at Universitas Trisakti for funding this research.

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