The Effect Of Worm Density In Vermicomposting Of Vegetable Waste And Cow Manure Using Lumbricus Rubellus

Iasha Diana Putri, Dwi Indrawati, R. Ratnaningsih

Abstract: Cibodas Village, Pasirjambu district, Bandung Region is a place that has high potential in developing dairy industry and the producer of vegetables. The high interest of the citizens to plant various vegetables and raising cattle cause an increase in the amount of waste production. Cow manure (CM) and vegetable waste (VW) are mostly thrown into the river and made the water turned to green and thus contains a lot of bacteria. One way to handle this waste is to use vermicomposting method using Lumbricus rubellus. The purpose of this study was to observe the speed of waste degradation and quality of compost with variations of worm density and variations of row material. The research method using three variations of the worm density (1.5kg/m2; 2kg/m2; 2.5kg/m2), 4 variations of raw materials (100%CM, 100%VW, 50%CM and 50%VW, 30%CM and 70%VW). Biodegradation calculation is performed by calculating the percentage difference before and after the process of composting. The results showed that the worm density effect on the biodegradation of organic matter. Worm density 1.5 kg/m2 is the highest earthworm biomass and also giving a lower number of vermicompost. Variations materials 30%CM and 70%VW shows that the Lumbricus rubellus worm has high potential to reduce waste into compost and the analysis result showed that nitrogen, phosphorus, potassium and C/N ratio has met the standard of SNI 19-7030-2004 (2,201%; 1,348%; 2,741%; 9,523). Furthermore, because of the analysis result has fit into the standard, it can be known that vermicomposting can be used for the growth and development of healthy plants.

Index of Terms: Biodegradation, Cow manure, Lumbricus rubellus, Vegetable waste, Vermicomposting, Worm density

1 INTRODUCTION

Cibodas village, Pasirjambu district, Bandung region is a place that has high potential in developing the livestock industry one of them is a dairy farm. With the increasing demand for milk, cow productivity will be higher and will increase the production of its manure. Cibodas Village is also a vegetable producing area. The high interest of the citizens to plant various vegetables because of easy maintenance and a long harvest time cause the amount of dried leaves waste from the crop. Vegetable waste is also a good material for composting because it is a pure organic material, relatively easy to decompose the waste compared with the garden waste that is usually high in lignin. Cow manure has long been used in Indonesia to preserve soil and help plants grow. Researcher [1] mention, cow manure contains high nutrients and is one of the best natural fertilizer materials for gardening, three essential nutrients required by plants for its healthy growth, like Nitrogen, Phosphor and Potassium. Further [1] research, shown that cow manure has about 3% nitrogen, 2% Phosphor, and 1% Potassium. According to Researcher [2], vegetable waste that remains has yet to get special handling and will cause environmental pollution. The composition of the most common vegetable waste that can be found are, spinach, chinese mustards, leaf mustards, cabbages, and other vegetables.

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The waste is mostly disposed by the farmer to the river or dumped on the garden, which will cause the color of the river water turn into dark green and contain bacteria, in a short time the river will also undergo siltation and the water quality will be reduced. One way to handle vegetable waste and cow manure is with Vermicomposting method. Vermicomposting involve physical and biochemical action of earthworms in changing organic materials. The goal of this vermicomposting is to get worm biomass and vermicompost. one of the factors that affect the decomposition process is the warm population density calculated from the number or weight of earthworms per m2. Lumbricus rubellus earthworm is one of the most active worms in degrading organic matter in the soil. Vermicomposting is a mesophilic process that uses microorganisms and earthworms that are active at the temperature of 10°C up to 32°C (the temperature of moist organic material). The process is faster than composting because the organic material will pass through the earthworm's gut according to [3]. According to Researcher [4], from the content of the elements, vermicompost is much better than anorganic fertilizers because almost all of the nutrients needed by the plantation are available. Therefore, vermicompost is able to enhance and improve the quality of the crop production. So the purpose of this study is to determine the elimination cow manure and vegetable waste using Lumbricus rubellus worms to see the worm population density.

2 RESEARCH METHODOLOGY

The research was carried out for five months, starting in February 2019 until July 2019 in the village of Cibodas, Pasirjambu district, Bandung. For laboratory necessities conducted at the Laboratory of the Research Center for Tea and Quinine (PPTK) Gambung and Environmental Laboratory at Environmental Engineering Building K, Campus A.

Preparation and Variations of Materials

The tools used in this study are baskets, shovels, sacks, buckets and analytical balance. Materials used are 1 Amonth

old Lumbricus rubellus worms that were obtained from a breeder worms in Lembang as much as 15 kg, bio-activator EM4, 480 kg of cow manure, 544 kg of chopped vegetable waste. Vermicomposting is done using a basket with a size of 0.5 m x 0.5 m x 0.2 m. Basket size used in this study can be seen in Figure 1.

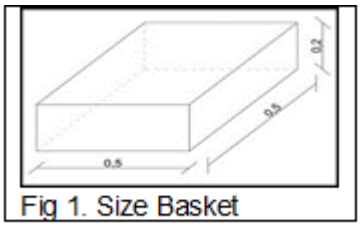

Fig 1. Size Basket

Before conducting this research, all the materials were analyzed to determine the content of those material. The results of the analysis of the materials can be seen in Table 1.

TABLE 1.
RESULTS OF LABORATORY ANALYSIS (PRE RESEARCH)

Parameter	Cow manure	vegetable
C-org (%)	45	26.1
Nitrogen (%)	1.23	3.39
P2O5 (%)	0.253	1.04
K2O (%)	0.667	3.64
C / N ratio	36.6	7.69

The fermentation process lasts for 7 days and vermicomposting process lasts for 30 days. On the base of the box is the place for the worms or called bedding that use silage from the leftover of animal feed. The variation of materials and densities used are as follows
M1 = 100% cow manure
M2 = 100% vegetable
M3 = 50% Cow manure 50% vegetable
M4 = 30% Cow manure 70% vegetable
D0 = Control
D1 = density of 1.5 kg/m2 (375 grams worms)
D2 = density of 2 kg/m2 (500 grams worms)
D3 = density of 2.5 kg/m2 (625 grams worms)

Biodegradation calculations is done on each basket, reduction is obtained by calculating the weight percentage of the initial compost and weight after vermicomposting process ends.

3 RESULTS AND DISCUSSION

Based on observations made during the 30 days of the study produced the data stocking density treatment effect of earthworms on the biodegradation of organic waste into compost that can be seen in Table 2

TABLE 2.
TREATMENT EFFECT OF ORGANIC WASTE BIODEGRADATION

Variation	Variation	Bio-conversion	Worm Weight Before	Worm Weight After
D0	M1	34%	-	-
	M2	32%	-	-
	M3	37%	-	-
	M4	39%	-	-
D1	M1	44%	375 gr	434 gr
	M2	46%	375 gr	419 gr
	M3	51%	375 gr	383 gr
	M4	56%	375 gr	384 gr
D2	M1	41%	500 gr	430 gr
	M2	42%	500 gr	448 gr
	M3	53%	500 gr	440 gr
	M4	62%	500 gr	431 gr
D3	M1	46%	625 gr	537 gr
	M2	46%	625 gr	575 gr
	M3	63%	625 gr	581 gr
	M4	63%	625 gr	512 gr

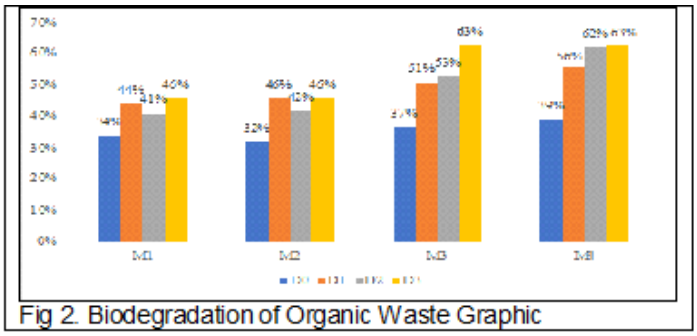
Fig 2. Biodegradation of Organic Waste Graphic

From the above data it can be seen that the highest biodegradation with is process D3M3 and D3M4 with a value of 63%. The high biodegradation results showed that the more worms entered, the more organic matter is being degraded. The lowest biodegradation contained in D0 where no worms were included so that the biodegradation of organic matter run longer. In process D1, the biodegradation is lower compared with process D2 and process D3, because the worm biomasses that are used is also lower. The weight of earthworms effects the weight of feed consumed. Basically, the lower the weight of earthworms the less food consumed, because there are many foods that have not been consumed. When viewed from the growth of earthworm biomass, process in D1 indicates the increase of biomass while in process D2 and D3 showed a reduction of biomass earthworms. Haukka, 1987 in [5], state that the conditions of low population density, growth of worms will be good but the decomposition process will be slowed down. Earthworms will stop eating when full, no matter how much food is available. On the other hand, if the population density is too high, the decomposition process will run very fast at first and slows down in a short time. Earthworms will suffer the limitations of food, their growth will be slowed down and die. This will reduce the earthworm biomass. The variation of materials also showed a difference of feed worms, data treatment M4 material variation in each density has a high enough value with an average of 55%, so it can be seen that variation of 30% cow manure and 70% vegetable is the best variation because the earthworms eat most of the materials. According to [6], Lumbricus rubellus worms are a powerful tool with high potential to convert vegetable waste and agro-industry waste into value-added ingredients. According to research done by [7], the average maximum individual biomass at a lower population density may be due to the availability of more food and less competition for food. The growth rate of earthworm is inversely proportional to population density. Worm with a lower population density reaches a higher biomass, while worms with a higher population density reaches a lower biomass. In the process of vermicomposting, there are supporting data to obtain optimal results, that are pH, temperature and humidity.

pH measurement

The degree of acidity (pH) can describe the process of waste decomposition by microorganisms and worms. pH measurement media as one of the factors of the worm's life and the performance of the worm in vermicomposting method. During the process, the pH of the material fluctuations indicate that the decomposition process is going well. The observation of the pH during research on the variation of 30% cow manure and 70% vegetable can be seen in Figure 3.

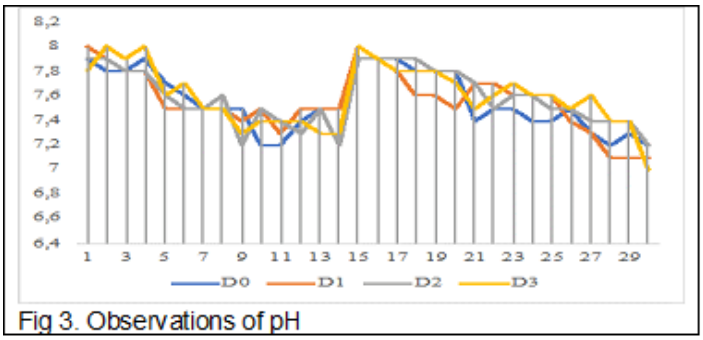

Fig 3. Observations of pH

In variations density of 1.5 kg/m2, a decrease in pH at the beginning of the process occurs on day 1 to day 6 in the pH range from 7.70 to 8.00 and the pH back fluctuated until the 14th day in a pH range from 7.40 to 7.60. On day 15, the pH of the material rises again in the range of 7.80 to 8.00 because there is an addition of material, then the pH will experience fluctuations in the pH range from 7.20 to 7.50 and stabilized towards neutral pH until day 30, where the process of decomposition by microorganisms and worms have been completed. The increase and decrease in pH in the process of vermicomposting waste occur due to decomposition by microorganisms and worms. The increase in pH also occurs because the initial characteristics of materials. pH decrease occurs because microorganisms and earthworms have been completed in degrading the waste, seen on the 30th day when pH of the media drops towards neutral pH of 7. According to [8], a decrease in pH occurs due to the mineralization of nitrogen and phosphor into nitrite/nitrate and orthophosphate. Other than that, the biodegradation of organic matter into organic acids can lower the pH.

Temperature measurement

During the vermicomposting process there will be changes in temperature in the compost. Changes in temperature is a sign that there are activities of microorganisms to decomposing organic matter. According to Dewilda and Firsti [9], the compost is said to be mature when the temperatures is ≤30°C. Temperature is an indicator of the dynamic activity of microorganisms on the raw materials. The higher the temperature, the more consumption of oxygen and the faster decomposition process by microorganisms and worms. The observation of the temperature during research on the variation of 30% cow manure and 70% vegetable can be seen in Figure 4.

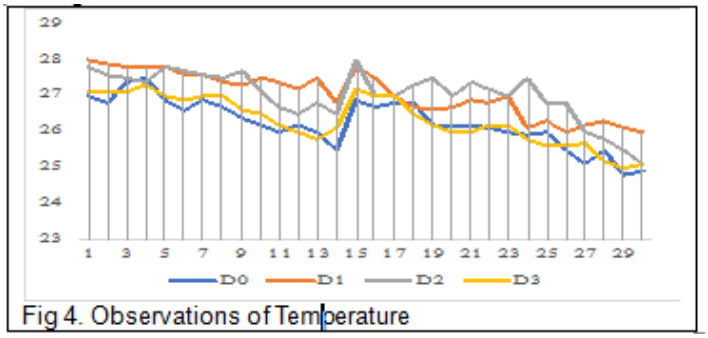

Fig 4. Observations of Temperature

In variations density of 1.5 kg/m2, day 1 until day 4 the temperature of the compost is still within the range of normal and stable temperature that is equal to 27.5 to 28°C, and then on the 5th to the 9th day the temperature dropped down to a range from 27 to 27.4°C. On day 10 to day 14 the temperature fluctuated but gradually decreased with a temperature of 26.5°C, on the 15th day, the compost temperature rose in number by 27.7°C, then on day 16 to day 30, the temperature decreased gradually and reached a stable temperature in the range of 26 to 26.5°C. The increase in temperature causes extermination of harmful microorganisms. Vermicomposting process involves partial aerobic and anaerobic processes. During the vermicomposting process, mesophilic bacteria dominates, thereby increasing the temperature of the material. Mesophilic bacteria are replaced by thermophilic bacteria that can survive in temperatures 45°C. Once the temperature drops, mesophilic bacteria become active again according to [10]. Researcher [11] said that in conditions of extreme temperature, earthworms tend to hibernate and migrate to the deeper layers of soil to cover.

Humidity measurement

Soil moisture plays an important role in the supply of oxygen in the process of vermicomposting. Humidity greatly affects the activity of microorganisms and earthworms. Appropriate humidity will make the process of waste biodegradation takes place optimally. The observation of moisture during research on the variation of 30% cow manure and 70% vegetable can be seen in Figure 5.

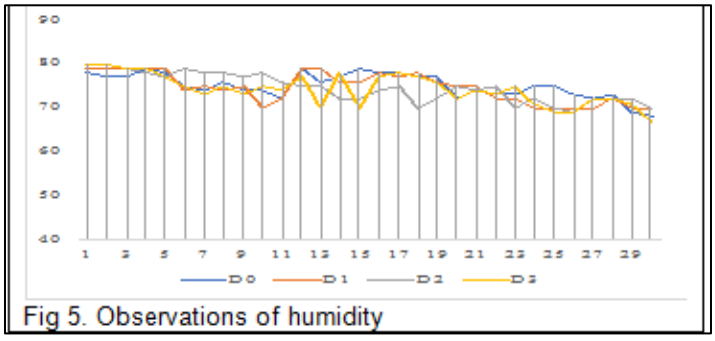

Fig 5. Observations of humidity

In variations of the density of 1.5 kg/m2, day 1 and 2nd, the humidity level in compost is in the range of 65-70%, then on day 3 to day 8, humidity stabilize at 65%, on day 9 until the 14th day, the humidity fluctuated but gradually fell to 55%. On the 15th day, humidity levels increased in number by 70%, then to the end of the decomposition process on the 30th day humidity gradually dropped to the range of 47-50%.Researcher [12] stated that the evaporation of water can

occur due to several factors, such as solar radiation, wind, humidity, temperature and transpiration by plant roots, which will be released into the air in the form of water vapor through leaves. Researcher [13] found optimal humidity is 40-60%. Humidity below 40% will result in decreased activity of microorganisms and if the humidity is greater than 60%, the air volume will be reduced and there will be an anaerobic fermentation which can cause bad odor. According to [14], the optimum moisture for the worm in vermicomposting is 50-80%.

Quality of Vermicompost

Vermicomposting methods can alter the chemical properties of raw materials with the help of enzymes in the gut of the earthworm. The changing process of the chemical in compost from vermicomposting result is also a result of the incorporation activity of microorganisms with earthworms. Materials that have been consumed by the worms will facilitate the microorganisms for subsequent processes. The results of vermicomposting are usually more nutritious than the usual composting results.

The results of the laboratory analysis of compost is as follows:

TABLE 3.
COMPOST ANALYSIS

Variation	WC (%)	N (%)	C-org (%)	C/N ratio	P (%)	K (%)
D1M1	7.132	1.401	21.01	15	0.546	1.206
D1M2	8.702	2.096	21.30	10.16	1.623	4.217
D1M3	8.720	1.886	20.55	10.89	1.119	2.707
D1M4	8.420	2.201	20.96	9.523	1.348	2.741
D2M4	8.212	2.123	20.89	9.843	1.310	2,008
D3M4	8.354	1.976	18.84	9.535	1.333	1.766

As shown in table 3, it can be seen there are comparison in result of vermicompost and analysis result of the material. Some parameter such as N, P, K increase after vermicomposting process. Other than that, some parameter reduces such as C and C/N ratio. Before the vermicomposting process, the value of C-organic in D1M1 is 45%, after the process is done the C-organic value fell to 21.01%, as for D1M2, the C-organic before the process is 26.1% and at the end of the process dropped to 21.30%. Earthworms will consume organic material including carbon and thus the activity of microorganisms to degrade the substrate is under aerobic conditions. These conditions are accelerating the transformation of organic material and mineral change to be easily absorbed by plants according to [15]. Total nitrogen value prior to the process in D1M1 is 1.23%, after the process ends the N value rose to 1.401%. For D1M2 the values of N before the process is 3.39% and decreased to 2.096%. Researcher [16], total N reduction is possible due to their consumption of nitrogen by worms that will be converted into the form of protein. Organic nitrogen is needed by microorganism and worms in the metabolic processes. According to [17] the difference of nitrogen content on every variation of density and material caused by the intake of food in each individual affected by worms and symbiosis mutualism between microorganisms and intestinal mucus which is specificOn the value of total phosphor in cow manure increased after vermicomposting process from 0.253% to 0.546%. In vegetable phosphor values increased by 1.04% to 1.623%. The increasing value of phosphor in vermicompost showed mineralization during the process. In general, when organic materials pass through worm's digestive organs, most of the phosphor will be converted into a form of dissolved phosphor by enzymes in the digestive organs of worms that is the acid phosphatase and alkaline phosphatase. After that, phosphor is released by microorganisms in the form worm feces according to [18]. Potassium total values on the cow manure before the process is 0.067%, after the end of the process the K value rose to 1.206%. For vegetables K value before the process is 3.64% down to 4.217%. Researcher [19] argues, the increased value of K occurs because the rest of the plant of organic waste is a source of potassium, which can be classified as mobile elements not only in plant cells but also in plant tissues as well as in the xylem and phloem. C/N ratio is an indicator of maturity and agronomic quality compost. The C/N ratio in cow manure decreased after the vermicomposting process from 36.6 to 15. In the vegetable, the value of C/N is increasing from 7.69 to 10.16. The decreasing and increasing of C/N ratio caused by the declining rate in organic C and total N vary in vegetable waste. According to [20], the value of C/N ratio below 20 indicates that the compost has matured, while the value of C/N ratio is equal to or smaller than 15, indicating that the compost has a high agronomic value. The results of lab analysis of vermicomposting process in this study if compared to [6] research is relevant to the same material that upon mixing 50% of cow manure and 50% vegetables contain 1.25% N, 24.52% C-Organic, 0.24% P, 1.27% K and C/N ratio 19.62. Then in a mixture of 30% of cow manure and 70% vegetables contain 1.20% N, 32.60% C-Organic, 0.29% P, 1.27% K and C/N ratio 27.17. There are some parameters that have a higher value of this research, because the waste that used the same that cow manure and vegetable waste, only a different composition of vegetable waste. Although nutrient contained in organic compost do not have a significant increase, C/N ratio have a significant decline so that plants can absorb the substances much easier according to [21]. The use of fertilizers stabilized by biodegradation provide greater amount of nutrients for crops, because the nutrients are formed during the process of biodegradation according to [22].

4 CONCLUSION

The results showed that the variation of materials and worm density of Lumbricus rubellus on vermicomposting greatly affect the biodegradation of organic waste into compost. Vermicomposting can be one of the alternative waste treatment, because it can produces vermicompost biomass that can enhance and improve the quality of crop production, vermicomposting can also increase earthworm biomass that can be reused for subsequent vermicomposting method. Density 1.5 kg/m2 produce the highest earthworm biomass and at the same time giving a lower number of vermicompost. Cow manure material variation of 30% and 70% vegetable show that Lumbricus rubellus worm are very voracious and also show that Lumbricus rubellus worm have a high potential to turn vegetable waste and livestock waste into compost. The analysis result from all variations of the compost quality showed that C-organic, nitrogen, C/N ratio, phosphorus, and potassium, has met the standard of SNI 19-7030-2004. Furthermore, because the analysis result has fit into the standard, it can be known that vermicomposting can be used for the growth and development of healthy plants.

5 ACKNOWLEDGMENT

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