



Journal Homepage: - www.journalijar.com
**INTERNATIONAL JOURNAL OF
 ADVANCED RESEARCH (IJAR)**

Article DOI: 10.21474/IJAR01/3481
 DOI URL: <http://dx.doi.org/10.21474/IJAR01/3481>



RESEARCH ARTICLE

THE STUDY OF VERMICOMPOSTING OPTIMIZATION OF ORGANIC WASTE.

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Manuscript Info

Manuscript History

Received: 04 January 2017
 Final Accepted: 06 February 2017
 Published: March 2017

Key words:-

waste, vermicompost, earthworms

Abstract

The study of vermicomposting optimization of organic waste aimed to produce vermicompost from urban raw waste, and to select one of three kinds of worm which had significant effect in the production of vermicompost. The writers conducted a research during June to August 2012, by treating three varieties of worm named: G1 = *Lumbricus rubellus*; G2 = *Lumbricus terrestris*; G3 = *Eisenia foetida*, and used Fully Randomized Design (FRD) for each type of worms. The research variables were C/N ratio, C organic, N, P-2O5, and K2O. The writers analysed the vermicompost treatment results in the laboratory, followed by ANOVA. The researchers used gentong (barrel-shaped potteries) as a research tool; and obtained organic waste materials from the local landfill. The result showed that it was possible to produce organic fertilizer from urban waste materials with vermicomposting process using *Lumbricus rubellus*, *Lumbricus terrestris* and *Eisenia foetida*. Moreover, apparently, *Lumbricus rubellus* had the highest influence in the production of vermicompost.

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Introduction:-

Organic fertilizers are largely or entirely composed from organic materials which are derived from plants and animals that have been through a technical process. The fertilizers can be used to supply organic matter, and to improve the physical, chemical and biological soil [1]. Organic fertilizers can be made from waste, because it comprises of inorganic and organic materials. Organic waste consists of plant and animal materials which were taken from nature, or produced from agricultural activities, fisheries or other activities, these rubbish is easily described in the natural processes [2].

The use of waste as an organic fertilizer for direct application to soil generally experiences a variety of problems, for instance: (1) the waste contains inorganic material that is not biologically and easily weathered, such as: glass, plastic, metal, (2) trash has high level of C/N ratio, (3) the composition of organic waste varies too much, and sometimes there is a toxic compound [3]. Other problems are caused by sewage pollution of the environment by heavy metals and chemicals [4]. Toxic heavy metals such as As, Hg, Pb, and Cd can contaminate or damage the environment [5]. Heavy metals As, Cd, Pb, and Hg are very poisonous which can accumulate in crops such as rice, grass, vegetables, and other crops [6].

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Vermitechnology is a system in which earthworms are utilized for the bio-conversion of organic waste into vermicompost. Vermicompost has wide applications in organic waste management and has been proven to be an efficient method to manage organic waste materials with diminutive complexity and economic feasibility [7]. Vermicompost is a process to convert organic waste into fertilizer [8]. Taking into account that the organic waste and compost application in agriculture has many positive effects [9], so that it is necessary to conduct research on organic fertilizer with vermicomposting method by utilizing worms performance to process raw materials from waste. Based on the above facts, therefore, the study of vermicomposting optimization of organic waste was conducted, which aims to (1) produce vermicompost from urban waste materials, (2) select one of the three types of worms that have the highest influence in the process of vermicomposting.

Waste:-

Waste is an invaluable material flawed or damaged goods in manufacturing or fabrication, or from excessive materials which are rejected or discarded. Waste is also from discarded materials from human activities and natural processes which do not have economic value. It is the leftover of human day-to-day activities and natural processes that is solid. Specific waste is a waste that needs a special treatment because of its nature, concentration, and volume. Organic waste is waste consisting of plant and animal materials which were taken naturally, or produced from agricultural activities, fisheries or other activities, this kind of waste is easily described in vermicomposting processes.

Vermicompost:-

Vermicompost is a method of waste disposal which is costly effective, fast and environmentally friendly [10]. Urban waste can be effectively degraded by earthworms in vermicompost process resulting in the production of pathogen-free fertilizer [11]. Organic waste can be more useful by converting them into fertilizer using vermicompost process. Although the nutrients contained in the fertilizer having no significant increase, the the ratio of C/N undergoes significant decrease making plants easily absorb the substance. Vermicompost plays an important role in protecting the environment because it uses waste as its raw materials, helps building soil fertility and improves soil health for sustainable agriculture [12].

Vermicomposting is in the same page with the principle of healthy environment because it has the value of resource conservation and sustainable practices, as a process for handling organic residue which is an alternative approach in waste management, which is not dumped or incinerated but recycled [13].

In the composting process, the C/N ratio is one of the important parameters that give an indication of the decomposition rate, and it is proven that vermicomposting decrease the ratio of C/N significantly [14].

Vermicompost can significantly improve the growth and yield of vegetables and fruits. The effect of vermicompost on plant is caused by the quality of the mineral provided. It is also to regulate the growth of other components such as plant growth hormones, and to improve soil quality by increasing microbial activity [15]. Giving efficient conversion of organic waste, stabilizing the soil conditions, helping in reducing the population of microbial pathogens and heavy metal toxicity, relatively easy and inexpensive economical technology, as well as its function as the most environmentally safe nutritional supplement for organic crop production is many advantages of using vermicompost [16].

Earthworms:-

Lumbricus has flattened body shape, and body segments around 90-195. Klitelum lies in the 27th-32th segment. *Lumbricus rubellus* has relatively small body size with a length of 8-14 cm; the body color, especially the back, is light beige to reddish purple. Most part of the belly is beige, and tail is yellowish; the shape of dorsal is rounded and vertically flat; the number of segment on the klitelum are around 6 - 7 segments; the male sex hole lies in the 13th segment; its movement is slow; and its body contains 70-78% of water [17]. Meanwhile, *Eisenia foetida* is 3 – 10 cm in body length, 0.4 – 0.6 g in body weight, 50 – 55 days of lifespan, cocoon production is 1 in every 3 days, cocoon incubation is 20 – 23 days [16].

Research Method:-

The study began in June to August 2012. The place of extraction of urban waste materials was in the landfill of Sekoto Village, Badas Sub-district, Kediri regency. The vermicomposting research process was conducted in Lirboyo Kediri, East Java, Indonesia.

The experiment was carried out using three types of worms G1 = *Lumbricus rubellus*; G2 = *Lumbricus terrestris*; G3 = *Eisenia foetida*, each worm was treated repeatedly for approximately three times using fully randomized design (CRD). The experimental variable is the content of: C/N ratio, C organic, N, P₂O₅, and K₂O, statistically analyzed by ANOVA. Laboratory analysis for C organic was measured using the Walkley-Black method, N using the method of Kjeldahl, P and K using calorimetric and photometric methods, C/N ratio was calculated from the measured values of C and N, the elements of As, Pb and Cd using AAS (Atomic Absorption Spectrophotometry), and Hg using Cold Atomic Absorption of Mercury Analyser.

Gentongs (barrel-shaped potteries) were used as the container during the experiment, and the experimental materials were organic wastes and three types of worms namely *Lumbricus rubellus* and *Eisenia foetida*, both worms were imported from wormbreeders in Bandung regency of West Java, while *Lumbricus terrestris* were taken from Kediri, East Java, Indonesia.

Research Implementation:-

The study began in June to August 2012. The place of extraction of urban waste materials was in the landfill of Sekoto Village, Badas Sub-district, Kediri regency. The vermicomposting research process was conducted in Lirboyo Kediri, East Java, Indonesia.

The research was started from the preparation of organic waste as the medium and worm food. Worm could not live in a pile of garbage in landfills, the waste needed to be sorted between organic and non-organic waste. Organic waste was composted using EM-4 and was left for 30 days, then it was used for the research materials. These materials were tested in the laboratory before being used; the result was used as a control in the statistical analysis. Vermikomposting has been proven to be better technology than the compost and more suitable for the management and recovery of nutrients from urban waste [18].

Nine barrel-shaped potteries were placed on the ground randomly. Sand was used to keep the moisture by watering them every day. Low temperature and bright light condition will disturb the earthworm; however, when the temperature is warm and humid, it will be favorable for the worm [19]. The barrel-shaped potteries were filled with organic waste, each as much as two pounds, then one kilogram of worms per barrel was put inside of them. Earthworms eat variety of organic wastes, the number of foods per day is equal to his weight [20]. One kilogram of earthworms can process one kilogram of waste per day, and produces 0.5 pounds of earthworms' waste [17].

In every three potteries, they were filled with the same type of worm. G1.1, G1.2, G1.3 = *Lumbricus rubellus*; G2.1, G2.2, G2.3 = *Lumbricus terrestris*; G3.1, G3.2, G3.3 = *Eisenia foetida*. Next, the barrels were closed using gauze so that the worms could not get out.

After two days, all the contents of the barrels were removed and separated between worms and vermicompost. It was estimated, that the organic waste would have been eaten by the earthworms in two days. Earthworms refuse to stay in their own excrement (vermicast) for a long time and die if there is no food available [19]. In the end, Vermicompost in each treatment was collected to be tested in the laboratory.

Result and Discussion:-

The vermicomposts were tested in the laboratory of soil science, Faculty of Agriculture, University of Brawijaya, Malang, Indonesia, to obtain the value of the variables. Further, they were statistically analysed using ANOVA, the result is as follows:

The analysis of the organic C content from the three types of worm treatment is presented in Table 1.

Table 1:- The Organic C content

Treatment	C organic %
Control	22,2 b
<i>Lumbricus rubellus</i>	6,01 a
<i>Lumbricus Terrestris</i>	5,84 a
<i>Eisenia foetida</i>	6,03 a
5% LSD	0,59

Description: The numbers followed by the same letter are not significantly different at 5% LSD.

The content of C-organic before worm treatments was 22.2%, after the worm treatments of *Lumbricus rubellus*, *Lumbricus terrestris* and *Eisenia foetida*, all organic C content decreased to 6.01%, 5.84% and 6.03%, significantly different from the previous treatment. The decomposition process is the release of carbon from complex into more simple bonds due to the use of C elements by the organism to get their life energy through respiration and biosynthetic processes, releasing CO₂ to organic material so that the organic materials that have undergone the decomposition process will have lower levels of C, compared to the C levels of raw materials [21].

The result of N content analysis from the three types of worm treatment is presented in Table 2.

Table 2:- Total N content

Treatment	N total %
Control	0,49 a
<i>Lumbricus rubellus</i>	0,63 b
<i>Lumbricus Terrestris</i>	0,69 b
<i>Eisenia foetida</i>	0,76 c
5% LSD	0,06

Description: The numbers followed by the same letter are not significantly different at 5% LSD.

The content of N-total before worm treatment was 0.49%, and after the worm treatment of *Lumbricus rubellus*, *Lumbricus terrestris* and *Eisenia foetida*, all content of N-total increased up to 0.63%, 0.69% and 0.76%, significantly different from the previous treatment. This is caused by the weathering process of mineralization of organic matter involving the performance of enzymes that hydrolyze the protein complex that will increase the nitrogen content in the vermicompost [22], on the other hand, there is a simultaneous addition of nitrogen by worms in the form of mucus and excretory material, this process occurs in a high intensity so that the content of nitrogen will increase [18].

The result of the C/N ratio content from the three types of worm treatment is presented in Table 3.

Table 3:- The C/N ratio content

Treatment	C/N %
Control	46,08 b
<i>Lumbricus rubellus</i>	9,54 a
<i>Lumbricus Terrestris</i>	8,46 a
<i>Eisenia foetida</i>	7,93 a
5% LSD	6,52

Description: The numbers followed by the same letter are not significantly different at 5% LSD.

The C/N ratio before worm treatment was 46.08, however, after the worm treatment of *Lumbricus rubellus*, *Lumbricus terrestris* and *Eisenia foetida*, the content of C/N ratio decrease up to 9.54, 8.46 and 7.93, all of them decreased significantly. The decline of C/N ratio was caused by the decreasing number of carbon as well as the increasing number of nitrogen.

The decomposition process is the release of carbon from complex into more simple bonds due to the use of C elements by the organism to get their life energy through respiration and biosynthetic processes, releasing CO₂ to organic material so that the organic materials that have undergone the decomposition process will have lower levels

of C, compared to the C levels of raw materials [21]. The decreasing amount of C/N ratio is also due to the increasing content as the result of mineralization, a process that changes the organic nitrogen into inorganic nitrogen through the weathering process which involves the work of enzymes that hydrolyzes protein complexes, as well as the nitrogen that was produced from the worms' excrement [23].

P2O5 content analysis of the results of treatment of various worms are presented in Table 4.

Table 4:- The P2O5 content

Treatment	P2O5 %
Control	0,57 a
<i>Lumbricus rubellus</i>	0,97 d
<i>Lumbricus Terrestris</i>	0,78 c
<i>Eisenia foetida</i>	0,68 b
5% LSD	0,02

Description: The numbers followed by the same letter are not significantly different at 5% LSD. The P2O5 content before worm treatment was 0.57%. Nevertheless, after the worm treatment of

Lumbricus rubellus, *Lumbricus terrestris* and *Eisenia foetida*, all contents of P2O5 increased up to 0.97%, 0.78% and 0.68%, significantly different from the treatment before. The total P value at the end of vermicomposting process will be higher than the initial value at the beginning of the process, this indicates that there is Phosphorus mineralization process [18]. In general, when the organic materials is passing through the worms' digestive organs, most of the phosphorus will be converted into the form of dissolved P by enzymes in the worm's digestive organs, namely acid phosphatase and alkaline phosphatase. Afterward, the P element will be released by microorganisms in the worm excrement [24].

K2O content analysis of the results of treatment of various worms are presented in Table 5.

Table 5:- The K2O content

Treatment	K2O %
Control	0,04 a
<i>Lumbricus rubellus</i>	0,07 b
<i>Lumbricus Terrestris</i>	0,10 c
<i>Eisenia foetida</i>	0,07 b
5% LSD	0,013

Description: The numbers followed by the same letter are not significantly different at 5% LSD. The content of K2O before worm treatment was 0.04%; however, after worm treatment of *Lumbricus rubellus*, *Lumbricus terrestris* and *Eisenia foetida*, all content of K2O raised up to 0.07%, 0.10% and 0.07%. It was significantly different compared to the initial treatment. Probably, this was caused by the fact that the remains of plants from organic waste was a source of potassium, and potassium is classified as mobile elements not only in the plant cell, but also in the plant tissue, as well as in the xylem and phloem. Potassium can also be found in the cytoplasm. The existing K element on the substrate is converted into a soluble form by the existing microorganisms in the gastrointestinal worms [18], which makes the element of potassium higher than the control which was treated without any worm treatment.

The content of heavy metal in organic waste before worm treatment, and the heavy metal content in the vermicompost, is descriptively presented in Table 6 as follows.

Table 6:- The Heavy metal content

Treatment	Pb	Hg	Cd	As
Organic wastes (pre-treatment)	21	0,7	5	22
EM-4 treatment	20	0,6	4	20
<i>Lumbricus rubellus</i>	tu	tu	tu	tu
<i>Lumbricus terrestris</i>	18	tu	tu	tu
<i>Eisenia foetida</i>	tu	tu	tu	tu

Description: tu = not measurable with AAS analytical methods and CA3M

The result from the laboratory said that the organic waste contained 21 ppm Pb, 0.7 ppm Hg, Cd 5 ppm and 22 ppm As. Next, the composting process using EM4 was done resulting in the decrease of Pb content to 20 ppm, Hg to 0.6

ppm, Cd to 4 ppm and As to 20 ppm. After the worm treatment with three types of worms, vermicompost contained no heavy metal such as Pb, Hg, Cd and As, but the vermicompost with the worm treatment of *Lumbricus terrestris* that contained Pb approximately 18 ppm. It is assumed that the process of vermicompost can reduce heavy metal toxicity [12] [16]. Worms can absorb high concentration heavy metals; the process is, worms absorb the heavy metal particles at first, and coat each particle with a specific protein which prevents these metals to interact with the inside of the body [25]. Worms can also absorb arsenic [26].

Next, regression test was conducted to test the effects of the worms in producing the vermicompost and to find out which one is the most influential worm in producing the vermicompost according to the standard of Minimum Technical Requirements of Organic Fertilizer by Permentan (The Regulation of Ministry of Agriculture) No. 28 / SR.130 / 5 / 2009. The regression analysis showed the value of F was 82.493 > F table 6.23. It could be concluded that the vermicompost from urban solid waste can be made using *Lumbricus rubellus*, *Lumbricus terrestris* and *Eisenia foetida* worm. Presumably, there was one of the most dominant worms to produce the vermicompost, it had been

proven using the regression analysis to select the highest value on the coefficient of partial determination or r^2 using SPSS 17.0 for Windows, and the results are presented in Table 7 below.

Table 7:- partial results coefficient of determination regression analysis.

Treatment	r	r ²
<i>Lumbricus rubellus</i>	0,954	0,910
<i>Lumbricus terrestris</i>	-0,887	not significantly
<i>Eisenia foetida</i>	-0,905	not significantly

The analysis showed that the effect of *Lumbricus rubellus* was 0.910 or 91%. This suggested that *Lumbricus rubellus* had contributed partially to the production of 91% vermicompost fertilizer. While the coefficients of partial determination for two other variables were negative, the negative values were less influential or not significantly meaningful so it could be ignored. From the results of this analysis, it could be concluded that the *Lumbricus rubellus* was a worm that had the highest influence in the production process of vermicompost. According to [27], *Lumbricus rubellus* is a major waste eater and it is also considered as the biodegrader earthworm species, they are used throughout the world for waste degradation and being the most important and successful thing in the ecology management of urban organic waste.

Conclusion:-

- 1). It is possible that urban waste could be made into vermicompost using the three types of worm (*Lumbricus rubellus*, *Lumbricus terrestris* and *Eisenia foetida*.) However, this vermicompost must still be in accordance with the standard of Minimum Technical Requirements of Organic Fertilizer by Permentan (The Regulation of Ministry of Agriculture) No.28/Permentan/SR.130/5/2009.
- 2). From the study, among the three worms, *Lumbricus rubellus* showed the most significant influence in producing many important contents in the process of vermicomposting.

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