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Decomposition rate of pineapple peel waste by earthworms (*Lumbricus rubellus*, Hoff.) at different doses and water content

W Subchan^{1*}, S Winarso² and E Indriyanti¹

¹Biology Education Department, FKIP, The University of Jember, Indonesia

²Soil Department, Agricultural Faculty, The University of Jember, Indonesia

*E-mail : wachju.fkip@unej.ac.id

Abstract. Earthworms can be used as an indicator of fertility or soil quality. Its ability to decompose organic waste is very high. On the other hand, the organic waste generated by various human activities is enormous and continuous, including vegetable and fruit waste. In particular, pineapple peel waste which is a tropical fruit in traditional markets continues to be abundant and often becomes an environmental problem. The purpose of this study was to evaluate the rate of decomposition of pineapple peel waste by earthworms (*Lumbricus rubellus*, Hoff.) based on different doses and water content. The research was conducted at the Biological Conservation Laboratory, University of Jember. Pineapple peel waste was taken from traditional markets in the city of Jember. Combination treatment between pineapple peel waste water content (dry and fresh) and addition of pineapple peel waste per week as much as 140 g / week and 280 g / week. The soil medium used was 1500 g and inoculated earthworms with biomass 20 (± 0.53) grams at the beginning of the treatment. The evaluation of decomposition rate was based on soil organic C content and was evaluated weekly for 5 weeks. The results showed that the dried pineapple peel waste obtained a faster decomposition rate than the wet condition (fresh). The highest average speed in the treatment of pineapple peel waste with drying and weekly additions of 140 g / week was 86.76% per week and the lowest was in the combination treatment of wet pineapple waste (fresh) and weekly addition of 28 g / week of 63.17% per week. The decomposition rate at the beginning of incubation or the highest first week was followed by a decrease in speed based on the time of incubation.

1. Introduction

In 2018, global tropical fruit has reached an unprecedented peak of 7.1 million tonnes[1]. Pineapple (*Ananas comosus*) is a tropical fruit that is highly relished for its unique aroma and sweet taste. Ranked third behind banana and citrus, the demand for pineapple has greatly increased within the international market[2]. On the other hand, argue [3], that the pineapple (*Ananas comosus*) peels are agricultural plant residues that contribute to waste disposal problem and there is little information on their conversion to useful products.

Rotten fruit have a potential pollute to the environment. There is a large supply of about 5% per day. Based on observations in fruit selling points around the city of Kupang (markets, supermarkets, and traders), a day the rotten fruit is approximately 1-2 kg. If there are 20 fruit sellers, 10-20 kg of



fruit waste a day, or 700-1,400 kg a week. This means that is enough to produce fruit waste that has the potential to pollute the environment (smells bad) [4].

Food waste is a significant problem for environmental, economic and food security reasons [5]. Food waste is recognized as a global issue affecting the sustainability of the food supply chain. The unnecessary exploitation of natural resources (land, water, and fossil energy) and production of greenhouse gas emissions (GHG) make the reduction of food waste a key point [6]. The fruit and vegetable sector generate large amounts of waste, which poses both environmental and economic issues [7]. Fruit and vegetable processing industries account for the largest segment of food waste which is produced worldwide. The disposal of this waste requires a huge capital investment, majority of which is the transportation costs. This results in dumping and burning of these wastes in open fields [8].

Statistical analyses showed the presence of macro-decomposers to be an important factor for litter decomposition [9]. One of soil organism (macrofauna) which can be used to judge quality soil (bio-indicator) is earthworm [10]. Earthworms contribute to numerous ecosystem services provided by soils [11]. Earthworms benefit agriculture by providing several ecosystem services. Therefore, strategies to increase earthworm abundance and activity in agricultural soils should be identified, and encouraged [12]. Several short-term studies (≤ 90 days) have shown that earthworms can increase incorporation of residue carbon (C) into soil aggregates, suggesting reduced decomposition in the longer term [13]. Some earthworm species may be more effective in the decomposition process than others [11]. The primary decomposers *Lumbricus rubellus* and *Cylindroiulus fulviceps* strongly increased decomposition [9].

Handling of organic waste can occur with the help of earthworms *L. rubellus* Hoff. The degradation process carried out by earthworms has several stages which cause the degradation process to run faster and bring various benefits [14]. The purpose of this study was to evaluate the rate of decomposition of pineapple peel waste by earthworms (*Lumbricus rubellus*, Hoff.) based on different doses and water content.

2. Materials and methods

2.1. Experimental design

This research is a laboratory experimental study designed by following a randomized block design (RBD), conducted from September 3, 2015 to October 1, 2015. The research was conducted at the Biological Conservation Laboratory, University of Jember. The process of fermentation of pineapple peel waste and maintenance of *Lumbricus rubellus* Hoff. earthworms held at the Ecology Laboratory of Biology Education Study Program, Teaching and Education Faculty, University of Jember. The total organic carbon test was carried out at the Soil Laboratory of the Faculty of Agriculture, Jember University. The equipments used include: hoe, 10 mesh sieve, knife, swallow, analytical scale, rectangular plastic tub, large jar, digital camera, soil tester, soil temperature thermometer, plastic gloves, plant fiber sack, sprayer, measuring cup, ovens, furnaces and desiccators. The research materials consisted of: pineapple peel waste, *L. rubellus* earthworms, media (loose soil), and water. Pineapple waste comes from traditional markets in the city of Jember.

This research consisted of two treatments and each treatment, from three replications. The type of treatment in this study is the difference between fruit waste biomass as feed for earthworms. The first treatment presented 140 g / week of biomass and the second treatment presented 280 g / week of waste biomass. The soil medium used was 1500 g and inoculated earthworms with biomass 20 (± 0.53) grams at the beginning of the treatment. The evaluation of decomposition rate was based on soil organic C content and was evaluated weekly for 5 weeks.

2.2. Earthworms Treatment

The procedure of this study included acclimatization and identification of *L. rubellus* earthworms, selection of pineapple peel waste, preparation of earthworm tanks and media, earthworm inoculation in research media, feeding, earthworm maintenance, aliquot preparation techniques, and total organic carbon calculation. The study was conducted with two treatments with three replications. The first treatment was giving waste biomass as much as 140 g / week and the second treatment was giving waste biomass as much as 280 g / week. Each experimental unit consisted of 20 g of *L. rubellus* earthworm and 1500 g of soil medium. Observation of environmental factors (room temperature, soil temperature, soil pH and soil moisture) is carried out every day and the collection of waste biomass is carried out every week for 28 days.

Waste biomass parameter is waste biomass on the surface of the soil media which is not consumed by the earthworm *L. rubellus*. The remaining waste biomass was taken every week for a month for various treatments and replications. The calculation of the residual waste biomass uses the direct weighing method using an analytical scales.

2.3. Statistical analysis

The parameter of waste evaporation is the evaporation of water in pineapple peel waste for a week. Observation of waste evaporation parameters was carried out every week for various treatments with the direct weighing method using an analytical balance. The amount of waste evaporation can be obtained from the calculation:

$$E = \frac{A - S_{et}}{B + S_{e0}} \times 100$$

Description:

- E = Waste evaporation (%)
- A = total waste biomass after adding new waste (g)
- B = new waste biomass (g)
- S_{e0} = residual waste biomass on the waste aliquots at the early week (g)
- S_{et} = residual waste biomass on the waste aliquots at the end of the week (g)

The parameter of waste biomass consumed by *L. rubellus* earthworms is the net amount of waste biomass consumed by *L. rubellus* earthworms without being disturbed by the evaporation factor that occurs every week. Observation of these parameters is carried out every week using the direct weighing method using an analytical scales. The amount of waste biomass consumed by *L. rubellus* earthworms can be obtained from the calculation:

$$T = S_{et} - S$$

Description:

- T = waste biomass eaten by *L. Rubellus* earthworms (g)
- S_{et} = residual waste biomass on the waste aliquots at the end of the week (g)
- S = residual waste biomass on the surface of the soil medium (g)

The effectiveness of pineapple skin waste degradation can be obtained from calculations:

$$D_s = \frac{\sum T}{\sum P} \times 100$$

Description:

- D_s = effectiveness of waste degradation (g)
- T = waste biomass eaten by *L. rubellus* earthworms (g)
- P = waste biomass given to *L. rubellus* earthworms (g)

The Gravimetric method or dry ashing can be done in two steps. The first step in the analysis using the dry ashing method is weighing the sample for 5 g and oven at 105°C for 4 hours. The second step is that the sample is burned using a furnace at a temperature of 550°C for 6 hours. Organic material that burns will evaporate and the material left behind is inorganic material. This method is a semi-quantitative method because the weight loss during the ashing process only describes the organic matter content. The conversion factor $1 / 1.724$ is a general number for the relationship between organic matter and carbon. Calculation of organic carbon content is as follows:

$$C = \frac{1 - \frac{M_{abu}}{M_{kering}}}{1,724} \times 100$$

Description:

M_{abu} = biomass samples after sowing (g)

M_{kering} = sample biomass after oven (g)

The effectiveness of the organic carbon degradation of pineapple peel waste can be obtained from calculations:

$$D_{cs} = \frac{C_0 - C_t}{C_0} \times 100$$

Description:

D_{cs} = effectiveness of waste organic carbon degradation (%)

C_0 = organic carbon content at the beginning of the study (%)

C_t = organic carbon content at the end of the study (%)

Observation data were calculated using Microsoft Excel to determine the effectiveness of organic carbon degradation in fruit waste by *L. Rubellusearthworm*.

3. Results and Discussion

3.1. Decomposition Process

Earthworms are known as decomposers and ecosystem engineers or soil engineers who are effective, so they are often said to be the dominant factor in soil fertility or quality. According to [15], earthworms are soil macrofauna that are currently widely cultivated for various purposes interests. The role of earthworms as soil macrofauna plays an important role in its ecosystem.

The result of this research, earthworms were used as a decomposer of organic waste in the form of pineapple peels which are widely used in traditional markets. The results of the combination research of water content treatment (wet and dry) with the amount of addition based on weight (140 and 280 g per week) showed that the worms in decomposing the waste were faster in the combination of dry waste and adding 140g per week. This is known from the amount of residual biomass measured in the first week, which is the smallest or least remaining amount or also means the largest amount of decomposition (Table 1). In this combination as much as the initial administration of 140 g in one week remaining 3,268 g or decomposed as much as 136.73 g and in the percentage get the result as much as 97.66%; followed by giving 140 g in the wet form of 95.56%, adding 280 g of dry which is 93.29% and finally adding 280 g in wet conditions which is 82%.

This result is much higher than the natural litter decomposition in pine forests, which is 18.74 g per week [16]. The amount of decomposition in the first week was not the same as the second, third, and fourth weeks, namely the longer the decomposition time, the decreasing of the decomposition time. This decomposition reduction has the same pattern for different treatment combinations which are presented in full in Table 1.

Table 1. Combination of Pineapple peel waste biomass and water content treatment and addition in several weeks of incubation on residual biomass

Treatment combination		Residual biomass (g) on week:			
		1	2	3	4
Wet Biomass	140 g/week	6,219 (±511.52)	23,984 (±235.57)	56,968 (±1247.24)	74,491 (±658.27)
	280 g/week	48,540 (±691.38)	113,505(±3004.56)	167,465 (±8056.64)	236,638 (±1179.64)
Dry Biomass	140 g/week	3,268 (±328.66)	13,634 (±4218.86)	23,301 (267.37)	41,478 (±373.99)
	280 g/week	18,792 (±552.13)	35,128 (±666.26)	64,267 (±1968.47)	114,394 (±1035.34)

The percentage of earthworm decomposition of the combination of water content treatment (wet and dry) with the amount of addition based on weight 140 and 280 g per week if evaluated based on a 4 week average is presented in Figure 1. Based on Figure 1 shows that the highest average percentage of decomposition of dry combination 140 g / week reached 86.76% followed by average percentage of decomposition of dry combination 280 g / week reached 81.98%. The highest average percentage of decomposition of wet combination 140 g / week reached 75.37% followed by giving in dry combination 280 g / week reaching 63.17%. This shows that the dry condition of organic waste (pineapple peel) determines the decomposition process rather than the amount or amount of organic waste. In addition, the amount of organic waste that is composed can be balanced with the number or size of worms that are added.

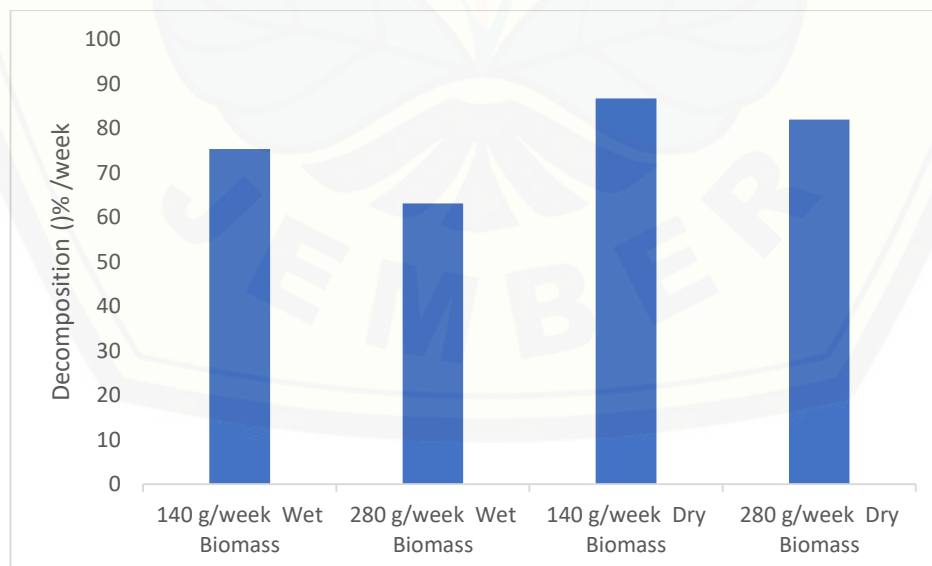


Figure 1. Decomposition percentage of pineapple peel waste biomass in various treatment combinations of water content and weight of addition

The decomposition of pineapple peel waste is very good for direct application in the field, especially agricultural soils because based on the results of research by [17]), in the laboratory to

determine the effect of earthworms on decomposition and nutrient cycling in coniferous forest soils, it shows that the results of decomposition will raise pH, N-available, and P-available and decrease the reduction biomes. According to [14], earthworms have a direct role in breaking down waste. These worms can break down plant waste pieces and mix them with soil. earthworms carry waste from the surface into the soil and repair the secretion of mucus which can improve soil structure. The gaps created by earthworms are called drilosphere, which is rich in organic matter and inorganic nutrients. Worms have cellulase and chitinase enzymes in their intestines that help break down cellulose and chitin polymers.

Earthworm biota activity physical properties among them, their movements can improve structure, aeration, and land drynation. While the role of soil biota on chemical properties land in between can affect element availability nutrients for plants as well absorption. In other words, the number of earthworms inside land is one factor from determining fertility and soil quality (soil bio-indicator)[10].

Research conducted by[14], handling of organic waste can occur with the help of earthworms *L. rubellus* Hoff. The degradation process carried out by earthworms has several stages which cause the degradation process to run faster and bring various benefits. The first stage in the degradation process is the stage where earthworms break down organic matter from a larger size to a smaller size, this process is called physical degradation. Furthermore, in the process of digesting food in the earthworm's body, especially in the intestine, various digestive enzymes are added and there are certain microorganisms that act as decomposing agents. The last stage is the occurrence of excretion in various forms. Second, the excretion of mucus as a result of the worm's response to environmental conditions, if the environmental conditions have high temperatures and decreased humidity conditions, the earthworms will secrete mucus. The main function of mucus is to assist the exchange of O₂ and CO₂ gases by diffusion on the surface of the earthworm's body, so that it is easier for earthworms to bind oxygen from the environment and diffuse into the body, while carbon dioxide is bound to be excreted from the body.

Biomass and populationearthworms can be used to assess soil quality based on pHsoil, C-organic, total N, and C / N ratioground water content. Existence of wormsland is one part ofmacro fauna which has the potential asvery soil quality bioindicatorinfluenced by the type of land management,types of comodities, and types of organic materials(mulch). Earthworm represents the macrofauanaplay a role in decomposer of materialsorganic, a producer of organic matter fromexcrement, improve structure andsoil aeration. Worm faeces soil contains a lot of organic matter which is high, in the form of total N and nitrate, Ca increment and Mg, pH, and percentage saturation of bases as well as ability base exchange[10].

3.2. Decomposition rate

The rate of decomposition is very important to be used as the basis for calculating the increasing waste management. In sustainable land management the rate of decomposition can be used as the basis for the period of giving or increasing or maintaining organic matter in the soil. The results of this study indicate that the average rate of decomposition of the combination of moisture treatment (wet and dry) with the amount of weight-based addition (140 and 280 g per week) is shown in Figure 2. Based on this figure, the first week of direct decomposition incubation is the highest for all treatment. The highest decomposition is dry conditions with the addition of 140g per week with the equation $y = -7.65x + 105.87$. $R^2 = 0.98$ and almost the same for wet conditions and adding 140g per week and dry conditions and adding 280g per week and small piling wet conditions and adding 280g per week with the equation $y = -11.47x + 91.83$. $R^2 = 0.97$.

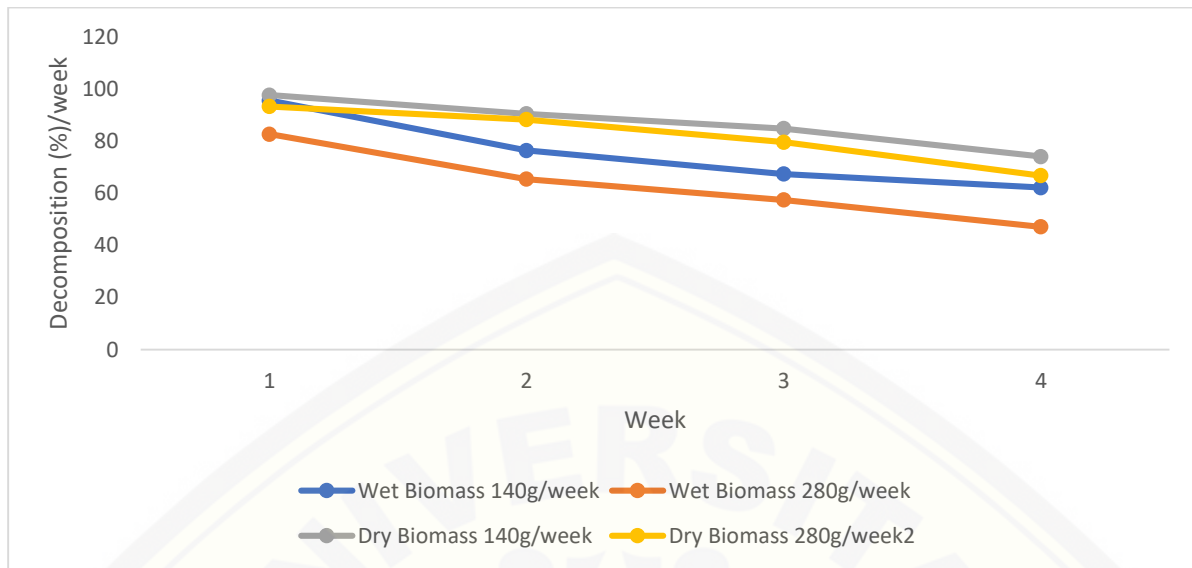


Figure 2. Decomposition rate of pineapple peel waste biomass in various treatment combinations of moisture content and weight of addition

The treatment of drying pineapple peel waste (ka) accelerated decomposition, compared to wet conditions or fresh (ka). Based on the amount of waste added, the results of the decomposition were more effective at adding 140 g / week with 20 grams of worms in 1500 g of soil media (1.3%) compared to adding 280 g / week. The addition of 140 g of pineapple peel waste in soil media or an addition of 8.43% gave a higher decomposition result than adding 280 g in the same medium or 15.56%. This showed that adding or adding pineapple peel waste as a source of excessive feed actually reduced the rate of decomposition. The results showed that the dried pineapple waste obtained a faster decomposition rate than the wet condition (fresh). The highest average rate decomposition in the treatment of pineapple peel waste with drying and weekly additions of 140 g / week is 86.76% per week and the lowest is in the combination treatment of wet pineapple peel waste and weekly addition of 28g / week of 63.17% per week.

Table 2. Average rate of decomposition of pineapple peel waste by earthworms (*Lumbricus rubellus*, Hoff.)

		Average	
Wet Biomass	140 g/week	75.37(±14.68)	%/week
Wet Biomass	280 g/week	63.17(±15.01)	%/week
Dry Biomass	140 g/week	86.76(±9.96)	%/week
Dry Biomass	280 g/week	81.98(±11.60)	%/week

One indicator of process effectiveness decomposition is the content of C and N and comparison C / N. Carbon compounds have distinctive characteristics that are not found in inorganic compounds, that is, can form chain of atoms and branching, while the elements N together with the P element is the main element forming major lipids and amino acids constituent of the cell wall. The decomposition process is the release of complex carbon bonds become simple bonds due to the use of the element C by organisms to obtain energy needs its life through the process of respiration and biosynthesis releasing CO₂, so organic material that has been undergoing a decomposition process will have the C content is

lower than the C content of the material fresh. The decomposition process is an enzymatic reaction which can be likened to the digestive process animals, apart from weathering (physical changes) as well the organic material is decomposed into and simple compound. During the decomposition process of fresh organic material into compost or vermicompost changes the status of nutrient content [17].

Based on the results of this research, *L. rubellus* earthworm can be used as the utilization of soil macrofauna in the decomposition process of organic waste such as pineapple peel waste. The rate of decomposition rate of *L. rubellus* earthworms against pineapple peel waste is more effective when applied with conditions where pineapple waste is dry or not mixed with other waste. This is because there are other organisms that can interfere with the activity of the *L. rubellus* earthworm in the process of degradation if the pineapple peel waste is not dry or isolated from other waste mixtures. The fermentation process facilitated the decomposition of the pineapple peel waste, where the texture becomes softer and can be easily digested by earthworms. This research will provide beneficial information in the processing of pineapple peel waste which has become a source of environmental problems.

4. Conclusions

Based on the research result and discussion we concluded that the dried pineapple waste obtained a faster decomposition rate than the wet condition, and the highest average decomposition showed at the treatment of pineapple peel waste with drying and weekly additions of 140 g / week is 86.76% per week. The *L. rubellus* prefer to the dried pineapple waste than the wet condition, and the amount of biomass weekly additions of pineapple peel waste should be concerned to increase the effectiveness the organic decomposition.

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