# Composting of Gambier Industrial Waste with the Addition of Cow Rumen and EM4 Activator using the Open Bin Method

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**Abstracts:** Gambir is included in the ten main export commodities of West Sumatra Province. The high production of gambier in West Sumatra produces solid waste in the form of remaining gambier leaves from the extraction process in the gambier industry which needs to be processed. This study aims to analyze the quality and quantity of compost from the gambier industrial solid waste in the form of gambier leaves (DG) from the production process. Composting using the open bin method with variations in the addition of cow rumen (RS) and EM4 bioactivator. This study consisted of six treatments, namely treatment 1 100% DG, treatment 2 100% DG + 200 mL EM4, treatment 3 50% DG + 50% RS, treatment 4 60% DG + 40% RS, treatment 5 70% DG + 30 % RS, treatment 6 80% DG + 20% RS. All composting treatments are given the addition of rice husks as a bulking agent so that the resulting compost becomes loose. Each composting treatment was carried out in duplicate. The results of all treatments for compost maturity with parameters of temperature, pH, color have met the SNI 19-7030-2004 standard with 44-70 days of composting time. The results of the compost quality analysis showed that all treatments met the SNI 19-7030-2004 standards regarding compost specifications from organic waste for parameters of moisture, C-organic, nitrogen, C/N ratio, phosphorus, and potassium except for the results of composting treatment 1 did not meet This C-organic parameter can be caused by treatment 1 there is no addition of raw materials or bioactivators. The quantity of solid compost yields 50-70% of the compost raw material. Composting with treatment composition 3, namely a mixture of 50% gambier leaves and 50% beef rumen is the composition of the fastest composting in composting with a long composting time of 44 days with the highest quality of composting results, namely 70.19% with a C/N ratio of 17.94%, P 0,38%, K 8.70% so that based on the scoring results obtained treatment 3 is the best composition.

**Keywords:** composting, cow rumen, EM4 bioactivator, gambier leaves, quality, quantity, open bin method

## 1. INTRODUCTION

The residue of human actions that results from numerous activities is referred to as waste. Waste from business and industrial residential activities could not be present. It is even more sophisticated and grows in amount in tandem with economic development. The gambier industry is one example of a labor dispute that has a substantial environmental impact. Gambir is one of West Sumatra Province's top ten primary export commodities. West Sumatra accounts for more than 80% of Indonesian gambier exports, with destinations including Australia, Bangladesh, Hong Kong, India, Malaysia, Nepal, Pakistan, Taiwan, Japan, Saudi Arabia, the Philippines, Thailand, and Singapore [1]. Gambier productivity varies by harvest, ranging from 65.5 kg to 432 kg/Ha [2]. According to data from the Ministry of Environment and Forestry in 2018, Indonesia's total organic waste is 59%, including 44% food waste and 15% yard waste. This organic waste comes from both the home and non-domestic sectors and has chemical and physical properties that make it suitable for biological processing [3,4,5,6,7,8]. However, only 7% of total garbage is recycled, and 69% of waste winds up in the Final Processing Site, leaving the remainder in the environment and unmanageable. As a result, adequate processing is required to address Indonesia's organic waste problem.

Based on research [9] obtained data for 2010 District 50 Cities, the high production of gambier in West Sumatra has caused problems with the resulting waste, combined with the increasing industrialization of gambier management in several areas such as the gambier industry in Pangkalan 50 Kota District. Pesisir Selatan Gambier has 28,325 hectares, produces 26,782 tons of gambier, and generates 241,038 tons of solid waste from gambier leaves. It can result in more gambier waste and significant issues. In typically, industrial gambier leaf debris is not treated and is simply discarded on garden area owned by the nearby neighborhood. Gambier leaf compacted garbage is difficult to organically disintegrate. Gambier leaf waste that has been treated organically takes 3-5 months to degrade since the gambier extract is extracted using ethyl acetate [9]. Aside from that, the gambier plant is abundant in fiber and polyphenol chemicals that work as antioxidants. The solid waste of gambier leaves is

difficult to break down and takes a long time to decompose, so if left alone, it could harm the ecosystem [2]. As a result, Gambier waste must be managed using methods such as composting.

Composting is an effort that can be made in the preparation of industrial gambier leaf waste. Composting through the household scale composting process with an open bin system is the approach used to manage industrial gambier leaf waste that has not been utilized optimally. This approach is employed because it is simple to implement and does not require a vast area, making land use more flexible and low-cost than other large-scale composting methods. The composting trash pile can reach a maximum height of 1.5m. The reversing method is more convenient than the open windrow and Caspary procedures. The available bin method is the right method to be used as a composting method to tackle industrial waste of gambier leaves.

Composting was accomplished by combining gambier leaf industrial waste with other raw materials such as beef rumen. Cow rumen is one of the slaughterhouse byproducts that has not been used properly and has even been thrown away, producing contamination in the environment. Cow rumen bacteria are made up of a variety of microorganisms, therefore they can be used. Some microorganisms, like as bacteria, fungi, and protozoa, can assist break down in the rumen fluid and are essential in composting. The addition of beef rumen raw materials can be an alternative in accelerating the decomposition of the gambier leaf industrial waste composting and can be an effort to overcome cow rumen waste that is not used optimally in animal slaughterhouses [10]

It can also utilize activators like EM4 as an option in composting gambier leaf industrial waste since EM4 works to speed up the growth of microorganisms and fermentation reactions in composting, making the gambier industrial solid waste easier to decompose. Then, rice husks are used as a bulking agent to boost soil porosity in the composting process, allowing air to flow freely even when the material porosity is low [11]. It thought that adding raw materials like beef rumen, EM4 activator, and rice husks would speed up composting.

## 2. MATERIALS AND METHODS

### 2.1 Research Preparation

The research preparation required in this study, namely:

**1. Selection of composting location and compost quality test location**

Took samples of industrial gambier leaf waste at the Gambir factory located in the base area of 50 cities, West Sumatra. In contrast, I took the beef rumen from the slaughterhouse located in the Koto Lalang Padang area, West Sumatra. carried out compost in Painan, West Sumatra, which is situated in the researcher's house. carriedAnalysislysis of compost samples at the Solid Waste Laboratory of the Environmental Engineering Department, Andalas University.

**2. Preparation of compost base material and activator**

The raw material for gambier leaves taken from the Gambir factory is located in 50 Payakumbuh cities, West Sumatra. The waste is taken directly from the gambier leaf waste disposal site, which is in the factory with chopped and hot conditions. In contrast, beef rumen's raw material is taken from animal slaughterhouses located in the Koto Lalang Padang area, West Sumatra. The rumen of the cattle born in the rumen of the freshly slaughtered cow. It is directly put into the sack to brought to the research site. The use of 200 mL of EM4 activator liquid is based on the Ministry of Agriculture's agricultural research and development agency's journal on making compost with activator EM4. The raw materials prepared are weighed according to the treatment and put it into the processing tank. Composting using the open bin method is carried out by adding the raw materials once and stirring twice a week. Making compost is carried out in 6 treatments of the compost raw material and then given rice husks as needed. The treatment of raw materials can see in Table 1.

**Table 1.** Composting Raw Material Composition

| Variation | Composision material (%) | | Activator | Weight (Kg) | |
|---|---|---|---|---|---|
| | DG | RS | EM4 | DG | RS |
| 1. | 100 | - | - | 32 | - |
| 2. | 100 | - | 200 mL | 32 | - |
| 3. | 50 | 50 | - | 17 | 36 |
| 4. | 60 | 40 | - | 19 | 27 |
| 5. | 70 | 30 | - | 25 | 19 |
| 6. | 80 | 20 | - | 24 | 12 |

### 3. Preparation of tools and materials for the open bin method

Can see processing tub with a width of 0.5 m, 1 m in length, and 0.5 m in height, made of wood, the size of the processing tub used based on the guidelines for the implementation of the 2014 3R waste processing site (TPS) in Figure 1

**Figure 1.** Open Bin Method

### 4. Preparation of test tools for compost maturity, quality, and quantity

To help check the maturity, quality, and quantity of compost, the tools listed in Table 2 are needed.

**Table 2.** Equipment for checking the maturity, quality and quantity of compost

| Item | Funcion | Quantity | Description |
|---|---|---|---|
| PH meter | Measure the pH of the compost | 1 unit | Maturity |
| Thermometer | Measure compost temperature | 1 unit | Maturity |
| Ruler | Measure the reduction rate of compost | 1 unit | Maturity |
| Wooden stick | Check water content | 1 unit | Maturity |
| Analytical balance | Weigh the weight of the compost to be tested | 1 unit | Quality |
| 100 ml measuring flask | Place the compost solution | 13 unit | Quality |
| Burette 10 ml | Titrate during nitrogen measurements | 2 unit | Quality |
| Erlenmeyer 300 mL | Place the solution during the titration process | 2 unit | Quality |
| Distillation apparatus | For the distillation process in nitrogen measurement | 2 unit | Quality |
| Kuvets and Spectrophotometers | Measure levels of C-Organic and phosphorus | 1 paket | Quality |
| Kuvets and Atomic Absorption Spectrophotometer (AAS) | Measure potassium levels | 1 paket | Quality |
| Measuring pipette | Measure the solution to be used | 1 unit | Quality |
| Balance | Measure the weight of the compost produced | 1 unit | Quantity |

### 2.2. Main Research

The steps taken in the primary research are:

**1. Making the processing tub**

The processing tub functions to enter the raw materials to be composted with a width of 0.5 m, 2 m long, and 0.5 m high.

**2. Composting using the open bin method**

Entering the raw materials into the processing tub. The raw materials that are entered have been chopped directly by the Gambir factory so that can now join them into the processing tub according to the variant of waste, beef rumen, EM4, and rice husks to the full and are reversed twice a week so that the air is evenly distributed in the composting process.

**3. Test the compost for maturity**

Observation of the maturity test is carried out every day. Monitoring of maturity includes temperature, pH, reduction level, humidity, color, texture, and odor based on SNI 19-7030-2004

**4. Remove the mature compost.**

The compost is removed from the hole after composting according to the compost ripeness standard, seen from the color, texture, smell, and temperature.

**5. Compost drying**

Compost is dried by being aerated in the shade or not exposed to direct sunlight

**6. Test the quality of the compost**

The analysis of the quality of physical elements (moisture content, temperature, pH, color, and odor) and macro factors (C, N, C / N, P, and K ratios) of compost aims to determine the variation of compost that has quality following compost standards. Based on SNI 19-70-30-2004.

**7. Test the compost quantity**

can do the compost quality test by weighing each variant's solid compost.

### 2.3. Processing and data analysis

**1. Analysis of raw materials, maturity, quality and quantity of compost**

Analysis of raw materials, maturity, quality, and quantity of compost Analysis of compost raw materials consists of a study of temperature, pH, moisture content, and C/N ratio. Compared The temperature and pH obtained with the research literature conducted by Sy, 2013 [9], while compared the moisture content and C/N ratio with the literature of Tchnobanoglous (1993) analysis of maturity and quality was compared with the literature on SNI 19-7030-2004, carried out the quantity analysis was by weighing the compost that had been dried and sieved and then calculated the percentage of the quantity.

**2. Selection of composting variations by scoring**

After analyzing the maturity, quality, and quantity of compost, scoring is carried out by referring to the literature, namely SNI 19-7030-2004 regarding the specifications for compost from domestic organic waste and the literature Center for Policy and Implementation Studies (CPIS) [12], 1992 regarding guidelines for making compost from destruction and the selection of the best compost variant by adding up the scoring results.

## 3. RESULTS AND DISCUSSIONS

### 3.1. Compost raw material analysis

Water content is an analysis that plays a vital role in the composting process because the composting water content must be in the range <50% (SNI 19-7030-2004) [13]. Test the moisture content of the raw materials to be composted will affect microorganisms' activity in the compost. So, it is necessary to measure the moisture content of the compost raw material

From the measurements that have been made, the water content of the Gambir sample is 50.16%, and the water content for the rumen sample is 59.27%. The C/N level of the gambier sample was 25.97, while the rumen's C/N ratio was 26.63. The experiment results, the water content, and the C/N ratio of the two samples met the quality standards, where the quality standard for the water content was 50-60%. In contrast, the C/N ratio had a quality average of 25-50. This concludes that we can use these two raw materials for composting. As shown in Table 3

**Table 3.** Initial characteristics of composting raw materials

| No. | Raw | Material | | Parameter Quality | Ket |
|---|---|---|---|---|---|
| | | Gambir | Rumen Sapi | | |
| 1 | Water content | 50,16 % | 59,27% | 50%-60% (** | Fulfill |
| 2 | C/N ratio | 25,97 | 26,63 | 25-50(** | Fulfill |

(**[14]

### 3.2. Compost Daturity Analysis

During composting, the compost maturity is monitored. Monitoring is done every day until the compost is considered ripe. Compost maturity monitoring parameters include temperature, pH, reduction level, humidity, odor, texture, and color, as well as composting time. The compost maturity analysis results shown in this section are the average of treatment A and treatment B.

Based on SNI 19-7030-2004 monitoring results of compost maturity, all composting treatments have met the maturity standard where the analysis temperature is less than 30 ° C or the same as groundwater temperature, neutral pH, the reduction rate of 20% -40%, as well as texture, color, and the smell of compost that resembles soil. The temperature range for mature compost for the entire treatment ranges from 26 ° C to 27 ° C. The pH of mature compost for all treatments is in the neutral range, namely 7 to 7.5. The reduction rate is in the field of 28% to 35%, and the texture, color, and smell of cooked compost resemble soil. The most extended treatment in the composting process is 100DG treatment with a composition of 100% gambier leaf industrial waste without the addition of an activator, which is 70 days.

In comparison, the fastest treatment is 50DG + 50RS treatment by mixing 50% gambier with 50% beef rumen, which is 44 days. Composting with beef rumen of an activator such as EM4 can accelerate composting because the gambier leaf industrial waste becomes easier to decompose. Can see compost maturity recapitulation in Table 4.

**Table 4.** Compost Daturity Recapitulation

| Treatment | Long Composting Time (Days) | Temperature (° C) | pH | Reduction Rate (%) | Moisture | Texture and Color | Smell |
|---|---|---|---|---|---|---|---|
| (100DG) | 70 | 26 | 7,1 | 29 | Less Moist | Likethe Land | The smell of soil |
| (DG+EM4) | 57 | 26 | 7,1 | 29 | Less Moist | Likethe Land | The smell of soil |
| (50DG+50RS) | 44 | 27 | 7,5 | 35 | Less Moist | Likethe Land | The smell of soil |
| (60DG+40RS) | 51 | 26 | 7,5 | 29 | Less Moist | Likethe Land | The smell of soil |
| (70DG+30RS) | 53 | 27 | 7,4 | 28 | Less Moist | Likethe Land | The smell of soil |
| (80DG+20RS) | 57 | 26 | 7,2 | 29 | Less Moist | Likethe Land | The smell of soil |

### 3.3. Compost quality analysis

Compost quality testing is carried out after the compost is ripe, that is, it has undergone the composting process, dried and sieved. Quality analysis based on SNI 19-7030-2004 includes physical and macro elements. Physical elements include water content, temperature, pH, color, and smell, while macro elements include C-Organic, Nitrogen, C/N Ratio, Phosphorous ($P_2O_5$), and Potassium ($K_2O$). Based on the compost quality test, it was found that all compost variations in composting met the compost quality standards based on SNI 19-7030-2004 both from physical and macro elements. It can be seen that the moisture content of the compost is ripein the range 13.37% - 18.35% temperature in the range 26-27 °C, pH in the neutral range, namely 7.1-7.5 with color blackish and smells like soil. For macro element parameters, the quality of compost for all treatments in this study met the standards except for the C-organic parameter for 100 DG treatment including, the moisture content between 18.30% days to 13.37%, the C-organic content ranged from 9.6% to 22, 8%, nitrogen levels ranged from 0.47% to 1.33%, C/N ratio ranged from 11.98% to 20%, phosphorus levels ranged from 0.13% to 0.41%, potassium levels ranged from 4.48% to 8.70%. All treatments have met the compost maturity standard according to SNI 19-7030-2004 except for the C-organic parameter for 100 DG treatment but the resulting value is close to the quality standard of SNI 19-7030-2004 this can be caused by the lack of carbon in the raw material and causing gambier to be difficult to decompose and require the longest time in the composting process. The recapitulation of compost quality test results for all variations of compost can be seen in Table 5 and Table 6.

**Table 5.** Quality Test Recapitulation (Physical Elements) of Composting

| Treatment | Water Content (%) | Temperature | pH | Color | Smell | Information |
|---|---|---|---|---|---|---|
| (100DG) | 13,37 | 26 | 7,1 | Black | Soil | Fulfill |
| (DG+EM4) | 18,30 | 26 | 7,1 | Black | Soil | Fulfill |
| (50DG+50RS) | 18,35 | 27 | 7,5 | Black | Soil | Fulfill |
| (60DG+40RS) | 17,6 | 26 | 7,5 | Black | Soil | Fulfill |
| (70DG+30RS) | 15,4 | 27 | 7,4 | Black | Soil | Fulfill |
| (80DG+20RS) | 14,88 | 26 | 7,2 | Black | Soil | Fulfill |
| **Quality standards** | **<50%** | **<30°C** | **6,8-7,49** | **Black** | **Soil** | |

**Table 6.** Composting Quality Test Recapitulation (Macro Elements)

| Treatment | C-Organic (%) | Nitrogen (%) | C/N | Phosphor (%) | Potassium (%) |
|---|---|---|---|---|---|
| (100 DG) | 9,6 | 0,47 | 20 | 0,16 | 4,97 |
| (DG+EM4) | 9,9 | 0,49 | 20 | 0,14 | 4,48 |
| (50DG+50RS) | 22,8 | 1,27 | 17,94 | 0,38 | 8,70 |
| (60DG+40RS) | 20,3 | 1,24 | 16,33 | 0,41 | 5,39 |
| (70DG+30RS) | 17,5 | 1,24 | 14,09 | 0,16 | 6,28 |
| (80DG+20RS) | 16,9 | 1,33 | 11,98 | 0,13 | 7,93 |
| **Quality standards** | 9,8-32% | > 0,4% | 10-20 | > 0,1 % | > 0,2% |

### 3.4. Compost quantity analysis

Quantity analysis of compost includes weight and percentage of compost. Solid compost is mature compost that has been sieved using a sieve with a sieve size of 3 mm.  can see the compost quantity recapitulation of all treatments in Table 7.

Based on the measurement of quantity, the percentage of compost maturity of all treatments in this study ranged from 52% to 70% with different raw material weights. Raw materials that only use gambier leaves weigh 32 kg with the resulting compost weight of 15.15 kg with a percentage of 52.66%, while raw materials for gambier leaves mixed with EM4 weigh 32 kg with the resulting compost weight of 14.80. Kg with a compost ratio of 53.75% shows that composting raw materials that only use gambier leaves gets a portion of compost that is not much different from composting raw materials for gambier leaves with the addition of EM4 activator. Still, natural materials added with beef rumen with 53 raw materials. up to 36 kg produces a compost weight of 15.80 to 15.05 kg with a compost

percentage of 70 to 57%. This shows that the quantity of solid compost is influenced by compost raw materials' type and composition. The most mature compost treatment is 50DG + 50RS treatment, consisting of 50% gambier leaves and 50% beef rumen. The piece of the raw material from compost also affects the quantity of compost. Compost consisting of a mixture of industrial gambier leaves and beef rumen is faster in decomposing.

**Tabel 7.** Compost Quantity Recapitulation

| Treatment | Raw material (Kg) | Compost Weight (Kg) | Compost Percentage (%) |
|---|---|---|---|
| (100 DG) | 32 | 15,15 | 52,66 |
| (DG+EM4) | 32 | 14,80 | 53,75 |
| (50DG+50RS) | 53 | 15,80 | 70,19 |
| (60DG+40RS) | 46 | 15,25 | 66,85 |
| (70DG+30RS) | 42 | 15,05 | 64,17 |
| (80DG+20RS) | 36 | 15,25 | 57,64 |

### 3.5. Selection of composting treatment

The selection of the best treatment is made by scoring. The compost quantity scoring is carried out based on the compost quantity percentage because the raw materials entered for each variation are different in amount. This is because the density of the waste is different. The weight of the raw material entered is also other depending on the composition of the raw material. Parameters with a quality standard are given a value of 1 if they meet quality standards and a deal 0 if not meet quality standards. For parameters that do not have quality standards such as composting time and quantity, scoring is based on ranking. Compost with a fast composting time and a high percentage of amount obtained the maximum score value and vice versa. Can see recapitulation and scoring results in Table 8.

**Table 8.** Recapitulation of Total Compost Scoring

| Treatment | Maturity of Compost | Compost Quality | Quantity of Compost | Total Score |
|---|---|---|---|---|
| (100 DG) | 7 | 4 | 1 | 12 |
| (DG+EM4) | 8 | 5 | 2 | 15 |
| (50DG+50RS) | 11 | 5 | 6 | 22 |
| (60DG+40RS) | 10 | 5 | 5 | 20 |
| (70DG+30RS) | 9 | 5 | 4 | 18 |
| (80DG+20RS) | 8 | 5 | 3 | 16 |

Table 8 shows a recapitulation of the total compost score with the number of scoring results from monitoring compost maturity, compost quality, and compost quantity. Based on this scoring results, obtained the highest score for the treatment of 50DG + 50RS with a total score of 22. The 50DG + 50RS treatment composition consisted of 50% gambier leaf industrial waste and 50% cattle rumen. The 50DG + 50RS treatment is one of the treatments that have a fast composting time and produces more compost quantities, so it gets the highest score. Thus, the compost raw material composition consisting of 50% gambier leaf waste and 50% beef rumen is the best composition with the highest total score of 22. It can use the results of this study as a suggestion for composting the gambier industrial solid waste.

## CONCLUSIONS

The results of the compost quality and quantity test with the composition of a mixture of the beef rumen and EM4 have met the quality standards for domestic organic compost SNI 19-7030-2004 and CPIS 1992, while the piece of compost raw materials only uses gambier leaves for the C-organic ratio parameter is not meet the quality standard, but the results of the compost quantity test have met. Compost composition that has the fastest maturity level, namely the treatment of 50% gambier leaves mixed with 50% beef rumen with a composting time of 44 days, while for the composition of the compost mixture of industrial leaf waste gambier with EM4 has a slower maturity level compared to ingredients mixed with beef rumen with a long composting time of 57 days. Composting with treatment composition 3, namely a mixture of 50% gambier leaves and 50% beef rumen, is the composition of the fastest composting in composting with a long composting time of 44 days with the highest quality of composting results,

namely 70.19% with a C / N ratio of 17.94%, P 0.38%, K 8.70% so that based on the scoring results obtained treatment 3 is the best composition.

## REFERENCES

[1] Gumbira, S. E. K., Syamsu, E. M., A.Herryandie, N., & Afni, D. L. R. (2009). AgroIndustri dan Bissnis Gambir Indonesia. 130–136.

[2] Fauza, H. (2011). Pengembangan Usaha Perkebunan dan Industri Gambir di Sumatera Barat: Peluang dan Tantanga. Reformasi Pertanian Terintegrasi Menuju Kedaulatan Pangan, 1–8.

[3] Dewilda, Y., Fauzi, M., Aziz, R., Utami, F.D. 2023. Analysis of Food Industry Waste Management based-on the Food Recovery Hierarchy and 3R Concept – A Case Study in Padang City, West Sumatra, Indonesia. Journal of Ecological Engineering, 24(7), 198 -208.

[4] Dewilda, Y., Riansyah A., Fauzi, M. 2022. Kajian Pengelolaan Sampah Makanan Hotel di Kota Padang berdasarkan Food Recovery Hierarchy. Jurnal Serambi Engineering, 7(4), 3959 – 3970

[5] Fauzi, M., Darnas, Y., Riansyah, A., Nanda, S. 2022a. Perencanaan Sistem Pengelolaan Persampahan Kawasan Wisata Budaya Nagari Koto Gadang, Sumatra Barat. Jurnal Serambi Engineering, 7(4), 4024 – 4035

[6] Dewilda, Y., Aziz, R., Fauzi, M. 2019. Kajian Potensi Daur Ulang Sampah Makanan Restoran di Kota Padang. Jurnal Serambi Engineering, 2(2), 482 - 487.

[7] Fauzi, M., Darnas, Y., Riansyah, A., Nanda, S. 2022a. Perencanaan Sistem Pengelolaan Persampahan Kawasan Wisata Budaya Nagari Koto Gadang, Sumatra Barat. Jurnal Serambi Engineering, 7(4), 4024 – 4035

[8] Aziz, R., Ruslinda, Y., Pratiwi, H.A., Fauzi, M. 2023. The Effect of Types and Sizes Variations of Market Organic Waste in Composting using Black Soldier Fly Larvae (BSFL). Revista de Gestão Social e Ambiental, 17(2)

[9] Sy, S. (2013). Pengomposan limbah padat industri kempaan gambir. Padang.

[10] Sundayanti, R. (2013). Pengaruh Cairan Rumen Sapi Potong Terhadap Kualitas Kompos Eceng Gondok (Eichornia crasipes L.). 1–8.

[11] Christina,Dewi, Dewi Mustika Mirasari, Antaresti, W. I. (2007). Pembuatan Kompos Secara Aerob Dengan Bulking Agent. Jurnal Teknik Kimia, 6(1), 21–31.

[12] Center for Policy and Implementation Studies (CPIS). (1992). Buku Panduan Teknik Pembuatan Kompos dari Sampah, Teori dan Aplikasi. Jakarta.

[13] Badan Standardisasi Nasional. (2004). Spesifikasi kompos dari sampah organik domestik. In Badan Standardisasi Nasional.

[14] Tchnobanoglous. (1993). Integrated Solid Waste Management. New York: Mc Graw Hill Inc.

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