Biosaintifika 14 (2) (2022): 226-235 p-ISSN 2085-191X | e-ISSN 2338-7610
Journal of Biology & Biology Education https://journal.unnes.ac.id/nju/index.php/biosaintifika

The Role of Bacteria in the Termites Intestine *Macrotermes gilvus* Hagen as a Biological Agent in the Degradation of Medical Mask Waste

Niken Subekti and Retno Wulandari

Department of Biology, Faculty of Mathematics and Natural Sciences, Univeristas Negeri Semarang, Semarang, Indonesia.

*Corresponding Author: nikensubekti@mail.unnes.ac.id

Submitted: 2022-06-04. Revised: 2022-07-16. Accepted: 2022-08-31

Abstract. The use of disposable medical masks during the Covid-19 pandemic can cause solid waste problems in the environment. The subterranean termite *Macrotermes gilvus* Hagen has the potential to degrade medical mask waste due to the presence of microorganisms in its intestines. The purpose of this study was to analyze the effect of adding starter bacteria from the intestine of the subterranean termite *M. gilvus* Hagen and the most optimal composting time in the degradation of medical mask waste according to SNI standards based on physical properties (color, smell, and texture), chemical properties (C-Organic content, N content, and C/N) compost. The results showed that the addition of bacterial starter from the subterranean termite intestine *M. gilvus* Hagen with a concentration of 50% and a composting time of 5 weeks gave the best compost yield according to SNI No. 19-7030-2004 because it has a dark brown color, crumb texture, smells like soil, 20.22% C-Organic content, 1.35% total N content, and 15.14% C/N content. This research can be recommended as an alternative solution for waste management using biological agents.

Key words Subterranean termites; *M. gilvus ;* degradation; Compost; Medical Mask.

How to Cite: Subekti, N. and Wulandari, R. (2022). The Role of Bacteria in the Termites Intestine *Macrotermes gilvus* Hagen as a Biological Agent in the Degradation of Medical Mask Waste. *Biosaintifika: Journal of Biology & Biology Education*, *14* (2), 226-235.

DOI: http://dx.doi.org/ 10.15294/biosaintifika.v14i2.37711

INTRODUCTION

The disease that caused by the SARS-CoV-2 virus (Severe Acute Respiratory Syndrome Coronavirus 2) is designated as a new pandemic for the whole world by the World Health Organization (WHO, 2020). In early April 2020, WHO issued a recommendation to wear masks for all people, both healthy and sick. The daily use of masks in Asia reaches 3716.20 million/day and the weight of mask waste per day is 1486.48 tons (Tripathi et al., 2020). Medical mask waste in Jakarta increased by 30% with the amount of waste reaching 12,750 tons per 60 days (Kojima et al., 2020). Medical mask waste generated during the COVID-19 pandemic poses a major environmental and health problem in many countries (Saadat et al., 2020).

Medical mask waste has basic ingredients that are difficult to decompose so it can be pollute the environment. So far, infectious waste treatment is carried out by burning using an initiator (S. Subekti, 2010). However, this method will produce pollutant gases such as dioxins, furans, CO2, CO, NOx, and SOx which are harmful to public health and can cause the phenomenon of acid rain if accumulated in the atmosphere in large quantities (Mollica & Balestieri, 2020).

An effort that can be done safely to reduce mask waste is to use the composting method. However, traditional composting will not be able to decompose medical mask waste quickly. Therefore, we need an alternative to speed up the composting time. The use of biological agents is one of the solutions.

Termites are one of the soil macrofaunae that have an important role as decomposers due to the presence of microorganisms in their intestines (Arinana et al., 2016). Microorganisms found in the subterranean termite *M. gilvus* Hagen are *Bacillus megaterium* and *Paracoccus yeei* (Subekti et al., 2018). According to Ghatge et al. (2020) bacteria from the genus *Bacillus* can biodegrade polyethylene. This shows that the bacteria in termite intestine have the potential to degrade medical mask waste. The use of waste-degrading microorganisms is an alternative solution to the problem of medical waste that is more environmentally friendly.

The purpose of this study was to analyze the effect of adding starter bacteria from the intestines of the subterranean termite *M.gilvus* and the length of time of composting on the physical properties (color, odor, and texture) and chemical properties (C-Organic content, total N, C/N, and water content) compost and to analyze the concentration of starter bacteria and the most optimal length of time in the degradation of good medical mask waste according to SNI standards. This research is expected to provide alternative solutions for overcoming the problem of medical mask waste in the midst of the Covid-19 pandemic by using biological agents.

METHODS

M.gilvus Termite Intestine Extraction

The termites used in this study were 1000 working caste *M.gilvus* termites. The termites used in this study were subterranean termites *M.gilvus*. The termites were taken from the forest around the Universitas Negeri Semarang. The termites that have been collected are sterilized on their body surfaces using 70% alcohol. The sterile termites were held by their bodies using macro tweezers and all of the termite intestines were taken aseptically using micro tweezers. The intestine that has been taken is then inserted into the microtube.

Microbial Culture of the Intestine of *M.gilvus*

The intestines of the subterranean termite *M.gilvus* which have been collected using micro-tweezers as many as 1000 pieces of intestine are then ground until smooth in a microtube. The finely ground termite intestines were added with 1 ml of distilled water and then centrifuged at 1000 rpm for 1 minute to separate the debris from the liquid. After that, 0.3 ml aliquot was poured into NA medium and then incubated at 30ºC for 4x24 hours. Bacterial colonies growing in the NA medium were then propagated in the NB medium. The process of a microbial culture from the intestine of the subterranean termite *M.gilvus* was carried out according to the method by Tay et al. (2010).

Bacterial Starters from the Intestine of *M.gilvus* Termites

Bacteria that grew on NA medium were taken using a loop and then implanted into 10 ml NB medium. Bacteria grown on NB medium were incubated for 2x24 hours at 30◦C. The starter solution that has been incubated is then stored in the freezer.

Determination of the Concentration of Bacterial Starter Solution

The starter solution for subterranean termite bacteria *M.gilvus* which had been propagated in NB media was then diluted with various concentrations of 0%, 30%, 40% and 50%. 0% concentration starter solution made of 100 ml NB will be used as a control. The starter solution concentration of 30% was made by dissolving 30 ml of the starter stock solution into 70 ml of NB. A starter solution of 40% concentration was prepared by dissolving 40 ml of starter stock solution into 60 ml of NB. The 50% concentration was made by dissolving 50 ml of the starter stock solution into 50 ml of NB.

Composting

In this study, composting was carried out using the modified Takakura method using a hollow garbage bucket (Dewilda et al., 2019). Composting components consist of cardboard, husk pillows, and bucket covers. A comparison of the amount of compost and waste is adjusted to the ratio in the Takakura method, namely 60% compost: 40% waste (Al-khadher et al., 2021). Composting is carried out with a composition of 1200 grams of compost mixed with 400 grams of chopped medical mask waste and 400 grams of chopped leaf litter then added with 200 ml of starter solution or until the compost moisture reaches 60%. The starter solution in the large-scale composting test was 2 ml of starter added to 2 ml of molasses and dissolved into 100 ml of sterile distilled water.

The starter is dissolved in molasses and water in a ratio of 1: 1:50. This study used several variations of starter made using Nutrient Broth solution, namely 0%, 30%, 40%, and 50%. The parameters measured were temperature, pH, and humidity which were measured every 2 days. Other parameters measured were compost odor, compost color, compost texture, compost C/N content, carbon content, and nitrogen content. During the composting process, a stirring process is carried out every two days. Furthermore, the top of the compost is covered with a husk pillow, black cloth, and finally covered with a bucket lid.

Data Measurement

Temperature, Humidity and pH

Measurements of temperature, humidity, and pH were carried out during the composting process, namely 1 week, 2 weeks, 3 weeks, 4 weeks, and 5 weeks. weeks during the composting process. Data collection on temperature, humidity,

Table 1. Score of Physical Properties of Compost (Nurweni *et al.*, 2019)

Score	Texture	Color	Smell
1	Sticky clumping	Greenish brown	Like the original smell
2	Wet clumping	Grayish brown	Strong pungent
3	Dry clumping	Brown	Not too pungent
4	Start breaking	Dark brown	Smells like soil
5	Like soil	Blackish brown	Smells good soil

and pH was carried out using a 4 in 1 soil tester by inserting the electrode into the soil, then pressing the button on the soil tester, and then scaling the results.

Compost Chemical Quality Testing

The chemical quality of the compost consisted of water content, C-Organic content, total N content, and the ratio of C/N ratio of compost. This test was carried out at the BPTP Ungaran Laboratory.

Observation of the Physical Quality of Compost (Color, Smell, and Texture)

Observation of the physical quality of the compost was carried out every week. Color, smell, and texture are compared with the parameters of compost maturity according to SNI Number 19-7030-2004 (2004), namely: 1) Compost color: blackish-like soil, 2) Compost Texture: crumbs like soil and nothing else before composting, 3) Compost smell: like soil.

Data analysis

The physical quality standards of compost are black compost color, crumb compost texture, compost odor resembling earthy odor, neutral pH, and stable temperature. The chemical standards of compost are Total Nitrogen content (N-Total), Organic Carbon content (C-Organic) and C/N ratio of compost based on SNI 19-7030-2004. In this study, data on the physical quality of the compost and the chemical content of the compost were carried out with a two-way ANOVA test to determine the effect of concentration and duration of composting on the compost yield. After that, a post hoc test / Tukey HSD further test was carried out to find out whether there were significant differences between the treatment groups.

RESULTS AND DISCUSSION

Effect of Addition of Termite Intestine Bacteria Starter and Composting Time on Chemical and Physical Properties of Compost

The addition of termite gut bacteria starter and the length of time for composting affect the chemical properties (C-Organic content, total N, C/N, and water content) and physical properties (color, odor, and texture) of the compost. The effect of adding 50% termite gut bacteria starter and 5 weeks of composting gave the best compost results, namely C organic content of 20.22%, total N content of 1.35%, C/N content of 15.14%, and water content of 40.05%. In addition, physically the compost has a blackish brown color, crumb texture, and smells like soil. The results of this study were strengthened by previous research which stated that the treatment with the addition of 50% concentration of *M.gilvus* starter intestinal bacteria with a composting time of 5 weeks produced the best quality compost (Aini and Subekti, 2015).

Chemical Properties of Compost

The results of the ANOVA test on C-Organic data, total N data, C/N ratio data, and water content data showed that the significant value in the treatment was $0.00 < 0.05$, so it can be said that the difference in the concentration of the starter termite bacteria *M.gilvus* and the length of time for composting affected on C-Organic levels, Total N levels, C/N levels, and the moisture content of the compost. Furthermore, to find out the differences

Table 2. The Chemical Standards of Compost Based on SNI

Compost chemical parameters	SNI Criteria	
	Minimum	Maximum
C-Organic (%)	9.8	32
N Total (%)	0.4	-
C/N ratio	10	20
Water content (%)	-	50

Table 3. Results of the Analysis of Chemical Properties of Compost

Chemical Properties of Compost	Concentration of the starter bacteri (%)	Composting Time (Week)					
		0	1	2	3	4	5
Rate C-Organic	0	34.14 ± 0.14^{a}	33.92 ± 0.12^{ab}	33.54 ± 0.36^{ab}	32.43±0.39^{c}	31.13 ± 0.13^{d}	30.53±0.46^{d}
	30	34.14 ± 0.14^{a}	33.30 ± 0.13^{b}	32.26±0.24^{c}	31.28 ± 0.18^{d}	30.51 ± 0.44^{d}	28.17±0.18^{e}
	40	34.14 ± 0.14^{a}	31.09 ± 0.08^{d}	30.69 ± 0.16^{d}	28.17 ± 0.17^{e}	25.41±0.44^{f}	23.50±0.44^{g}
	50	34.14 ± 0.14^{a}	31.21 ± 0.08^{d}	30.53 ± 0.10^{d}	25.27 ± 0.10^{f}	23.28 ± 0.22^{g}	20.22 ± 0.23^{h}
Total N Content	0	0.88 ± 0.01^{h}	0.90 ± 0.005^{g}	0.91 ± 0.005^{g}	1.05±0.00^{ef}	1.06±0.005^{ef}	1.13±0.005^{d}
	30	0.88 ± 0.01^{h}	0.91 ± 0.005^{g}	1.04±0.005^{f}	1.07 ± 0.00^{e}	1.14 ± 0.00^{d}	1.20±0.01^{c}
	40	0.88 ± 0.01^{h}	0.92 ± 0.005^{g}	1.14 ± 0.005^{d}	1.15±0.005^{d}	1.2 ± 0.005^{c}	1.21 ± 0.00^{c}
	50	0.88 ± 0.01^{h}	1.15 ± 0.00^{d}	1.21±0.005^{c}	1.26±0.01^{b}	1.33±0.005^{a}	1.35±0.00^{a}
C/N level	0	38.73 ± 0.32^{a}	37.08±0.01^{b}	36.85 ± 0.02^{bc}	30.87±0.02^{d}	29.10 ± 0.01^{e}	27.21 ± 0.01^{f}
	30	38.73 ± 0.32^{a}	36.50 ± 0.02^{c}	30.88 ± 0.01^{d}	29.11 ± 0.01^{e}	27.26 ± 0.01^{f}	24.65 ± 0.02^{g}
	40	38.73 ± 0.32^{a}	30.87 ± 0.02^{d}	27.24 ± 0.02^{f}	24.46 ± 0.02^{g}	22.15 ± 0.13^{h}	20.10 ± 0.02^{i}
	50	38.73 ± 0.32^{a}	27.22 ± 0.01^{f}	24.53 ± 0.01^{g}	22.25 ± 0.00^{h}	17.54 ± 0.01^{j}	15.14 ± 0.02^{k}
Water content	0	60.80 ± 0.02^{a}	57.65 ± 0.02^{b}	54.64 ± 0.25^{c}	51.07±0.01^{e}	50.88 ± 0.01^{e}	48.36 ± 0.01^{f}
	30	60.80 ± 0.02^{a}	57.60 ± 0.01^{b}	54.57 ± 0.02^{d}	50.95 ± 0.01^{e}	48.38 ± 0.01^{f}	45.20 ± 0.02^{g}
	40	60.80 ± 0.02^{a}	54.60 ± 0.01^{CD}	50.94 ± 0.01^{e}	48.36 ± 0.01^{f}	45.19 ± 0.02^{g}	43.26 ± 0.01^{h}
	50	60.80 ± 0.02^{a}	54.55 ± 0.00^{d}	48.33 ± 0.01^{f}	45.15 ± 0.01^{g}	43.25 ± 0.01^{h}	40.05 ± 0.05^{i}

Superscript letters in the average column indicate a significant difference in each treatment group with an accuracy level of 5% (= 0.05) based on the Tukey test.

between treatment groups, the concentration of the starter termite bacteria *M.gilvus* and the length of time for composting were further tested using the Post Hoc Tukey HSD test. Data on the value of C-Organic content, Total N content, C/N content, and moisture content in the compost produced from the results of the Tukey HSD difference test are presented in Table 3.

C-Organic Levels

Based on Table 3 above, it is known that the average percentage of the lowest organic C-Organic content in the compost is the result of composting with the addition of a 50% concentration of termite gut bacteria starter. The low C-Organic content indicates that microorganisms can work actively in the composting process (Liu et al., 2021). In the control treatment (0% concentration of starter bacteria) the levels of C-Organic were significantly different from the non-control treatment group. This indicates that the starter concentration of termite bacteria *M.gilvus* affects the percentage of C-Organic content in the compost yield. Similar research conducted by Zhu et al (2019) states that the more microorganisms, the higher the degradation process of the waste to be processed.

The length of time for composting also affects the yield of organic C content in the compost. The highest levels of organic C are found in the compost with a time of 0 weeks because the material decomposition process has not occurred, so the microbes do not use the energy contained in the compost materials. The results showed that the longer the composting time, the lower the C-Organic levels. This result is supported by previous research which states that the dissolved organic carbon content in compost materials continues to decrease because microorganisms degrade the organic carbon into CO2 which will be released into the air and provide energy for their survival (Ren et al., 2019).

C-Organic content is one of the indicators of the decomposition process and fertilizer quality parameter because it can improve soil properties and structure and increase water storage capacity (Miao et al., 2021). One of the requirements for compost maturity according to SNI is the C-Organic content of between 9.8%-32%. Based on the results of chemical analysis that has been carried out, the best organic C content is found in compost with the addition of *M.gilvus* intestine bacteria starter with a concentration of 50% and 5 week composting time of 20.22%.

Levels N Total

The results of the analysis showed that the nitrogen content increased during the composting process. The largest increase in the percentage of C-Organic levels occurred in the addition of *M.gilvus* bacteria starter treatment with a concentration of 50% and a composting time of 5 weeks. The increase in nitrogen content occurs due to the degradation process of compost material carried out by microorganisms into ammonia and nitrogen (Yu et al., 2019). The level of N-total increases in the composting process due to the activity of microorganisms that decompose protein into amino acids, then ammonification occurs to produce ammonium which is then oxidized to nitrate (Hastuti et al., 2017).

The length of the composting process can also affect the total N content of the compost. Microorganisms responsible for the degradation of organic matter require large amounts of nitrogen for cell synthesis (Meng et al., 2020). This is also in accordance with previous research which states that the more nitrogen content, the faster the decomposition process of compost raw materials because microorganisms need nitrogen for their development (Trivana & Pradhana, 2017). High levels of available nitrogen indicate that the decomposition process is going well (Liu et al., 2017).

In addition, nitrogen levels also play an important role in the process of microorganism development because it is used for the formation of microorganism body cells during the composting process(Qiu et al., 2021). The results of laboratory tests for parameters of nitrogen content (N-Total) in all treatments have met the SNI (>0.4%) which is in the range of 0.88% - 1.35%. However, the compost with the best total N content was found in the composting results with the addition of *M.gilvus* intestinal bacteria starter at a concentration of 50% and a 5 week composting time of 1.35%.

Levels C/N

Based on Table 3 the largest decrease in the percentage of C/N levels occurred in the treatment with the addition of bacterial starter with a concentration of 50% and the composting time of 5 weeks, which was 23.59% compared to the control. In the control treatment (0% concentration of starter bacteria) C/N levels were significantly different from the non-control treatment group. This shows that the concentration of starter termite bacteria *M.gilvus* affect the percentage of C/N levels in the compost yield. At the beginning of composting, all compost variations had high C/N levels because the carbon had not been used by microbes for the composting process (Barapatre et al., 2020).

In the composting process, element C is needed as an energy source for the life of microorganisms, and element N is used for protein synthesis (Yommi Dewilda, Aziz, & Hasnureta, 2019).

The results of the research that has been carried out are following previous research which states that in the treatment with the addition of a 50% concentration of starter termite gut bacteria *M.gilvus* with a composting time of 5 weeks to produce the best quality compost (Aini, 2015). According to Hadiwidodo et al. (2019), During the composting process, a biochemical reaction occurs which remodels C into CO2 and CH4 which then undergoes evaporation, causing a decrease in carbon content (C).

Meanwhile, the degradation process of compost material by microorganisms produces ammonia and nitrogen compounds so that the N-Total content in the compost increases. With decreased C-Organic content and increased N-Total then the C/N ratio decreased.

C/N content is one of the important parameters that is usually measured to assess the maturity level of compost, the level of N mobility in the soil, and provide an idea of whether the material is weathered or not (Macias-Corral et al., 2019). C/N levels that meet SNI (10%-20%) are treatments with the addition of 50% starter concentration of macro termes gilvus termite bacteria with a composting time of 4 weeks, and 5 weeks. However, the compost with the best C/N content was found in the composting results with the addition of *M.gilvus* bacteria starter in the subterranean termite at a concentration of 50% and a 5-week composting time of 15.14%.

Water Content

In Table 3 The best water content results were found in compost with the addition of *M.gilvus* bacteria starter in the subterranean termite at a concentration of 50% and 5 week composting time of 40.05%. The decrease in water content can occur due to the evaporation process and the reversal process during composting, reducing the water content in the compost. Based on SNI, the water content in good compost is <50%. Water content in compost that is too high (> 60%) can inhibit the growth of microorganisms because water molecules will fill the air cavity resulting in anaerobic conditions that will cause odor and cause the death of microorganisms due to lack of

Table 4. Results of the Analysis of the Physical Properties of Compost

Physical Properties	Concentration of the bacteria's starter (%)	Composting Time (Week)					
		0	1	2	3	4	5
Texture	0	1.00 ± 0.00^{g}	1.67 ± 0.57^{fg}	2.00 ± 0.00^{efg}	2.33 ± 0.57^{def}	3.00 ± 0.00^{cde}	3.33 ± 0.57^{bcd}
	30	1.00 ± 0.00^{g}	2.00 ± 0.00^{efg}	3.00 ± 0.00^{cde}	3.33 ± 0.57^{bcd}	4.00 ± 0.00^{abc}	4.00 ± 0.00^{abc}
	40	1.00 ± 0.00^{g}	2.33 ± 0.57^{def}	3.00 ± 0.00^{cde}	3.67 ± 0.57^{bc}	4.00 ± 0.00^{ab}	4.33 ± 0.00^{ab}
	50	1.00 ± 0.00^{g}	3.00 ± 0.00^{cde}	4.00 ± 0.00^{abc}	4.33 ± 0.57^{ab}	5.00 ± 0.00^{a}	5.00 ± 0.00^{a}
Color	0	1.00 ± 0.00^{h}	1.33 ± 0.57^{gh}	2.00 ± 0.00^{fgh}	3.00 ± 0.00^{def}	3.00 ± 0.00^{def}	3.33 ± 0.57^{cc}
	30	1.00 ± 0.00^{h}	1.33 ± 0.57^{gh}	2.33 ± 0.57^{efg}	3.00 ± 0.00^{def}	3.67 ± 0.57^{bc}	4.33 ± 0.57^{abc}
	40	1.00 ± 0.00^{h}	1.67 ± 0.57^{gh}	3.00 ± 0.00^{def}	3.33 ± 0.57^{cd}	4.00 ± 0.00^{abc}	5.00 ± 0.00^{a}
	50	1.00 ± 0.00^{h}	2.00 ± 0.00^{fgh}	3.00 ± 0.00^{def}	4.00 ± 0.00^{abc}	5.00 ± 0.57^{a}	5 ± 0.00^{a}
Smell	0	1.00 ± 0.00^{f}	2.00 ± 0.00^{e}	2.00 ± 0.00^{e}	2.67 ± 0.57^{de}	4.00 ± 0.00^{bc}	4.33 ± 0.57^{ab}
	30	1.00 ± 0.00^{f}	2.00 ± 0.00^{e}	3.00 ± 0.00^{d}	3.33 ± 0.57^{cd}	4.00 ± 0.00^{bc}	5.00 ± 0.00^{a}
	40	1.00 ± 0.00^{f}	2.67 ± 0.57^{de}	3.33 ± 0.57^{cd}	4.00 ± 0.00^{bc}	5.00 ± 0.00^{a}	5.00 ± 0.00^{a}
	50	1.00 ± 0.00^{f}	3.00 ± 0.00^{d}	4.00 ± 0.00^{bc}	4.33 ± 0.57^{ab}	5.00 ± 0.00^{a}	5.00 ± 0.00^{a}

Superscript letters in the average column indicate a significant difference in each treatment group with an accuracy level of 5% (= 0.05) based on the Tukey test.

oxygen (Trisakti et al., 2018). In addition, excessive moisture content can also lower the temperature in the compost heap (Abdoli et al., 2019). If the water content is < 40% then the composting process will take a long time (Hermawansyah et al., 2021).

Physical Properties of Compost

In addition to the chemical properties of compost, this study also observed the physical properties of compost, namely the color, texture, and smell of the compost. The results of the physical analysis of compost are presented in Table 4. The results of the ANOVA test showed that the significant value in the treatment was 0.00 < 0.05, so it can be said that the difference in the concentration of the starter termite bacteria *M.gilvus* and the length of time of composting affected the physical properties of the compost, namely texture, color, and odor. Furthermore, to find out the differences between treatment groups, the concentration of the starter termite bacteria *M.gilvus* and the length of time for composting were further tested using the Tukey Post Hoc test. The data on the color, texture, and smell of the compost produced from the results of the Tukey difference test are presented in Table 4.

Texture

Based on the results of the analysis shown in Table 4, at the beginning of composting all compost had the same texture as the composted materials. Score 1 compost texture is sticky clumping, score 2 is wet clumping, score 3 is dry clumping, score 4 is start breaking, and score 5 compost texture is like soil. Compost with the addition of a 50% concentration of *M.gilvus* starter intestine bacteria had changed in texture to crumb like soil (score 5) in the fourth and fifth weeks. This was significantly different from the compost that was treated with the addition of *M. gilvus* starter bacteria at a concentration of 0%, which was still clumping even though it had been 5 weeks of composting. Meanwhile, the texture of the compost with the addition of 30% and 40% concentration of bacterial starter had a texture that did not clot (started to split) (score 4) (Figure 1).

The results showed that the higher the concentration of added bacteria, the faster the composting process occurred. During the composting process, compost material undergoes a process of decay and weathering that occurs with the help of microbes (Subekti et al., 2019). The composting process will release carbon dioxide (CO2), water, and heat energy which causes the texture of the basic compost raw material to change due to destruction and shrinkage of as much as 40-60% (Hapsoh et al., 2016). The final result of good compost has a texture like soil and the final shape does not resemble the basic ingredients of compost because it has been decomposed by microorganisms (Ismayana et al., 2012).

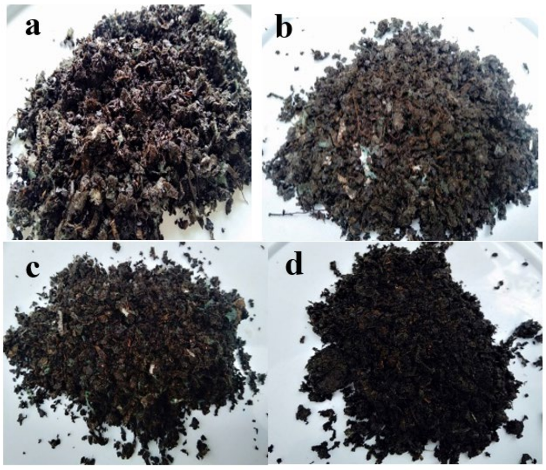

Figure 1. Compost results after 5 weeks of composting and the addition of termite gut bacteria starter *M.gilvus* with concentration: a) 0% (compost texture is dry clumping, the color is brown and compost smell is not too pungent) b) 30% (compost texture starts breaking, the color is dark brown and compost smells like soil), c) 40% (compost texture starts breaking, the color is blackish brown and compost smells good like soil), d) 50% (compost texture is like soil, the color is blackish brown and compost smells good like soil)

Color

Score 1 compost color is greenish brown, score 2 is grayish brown, score 3 is brown, score 4 is dark brown, and score 5 compost color is blackish brown. Based on Table 4 at the beginning of composting, all compost was greenish brown (score 1). The average color score showed that the compost with the addition of 50% concentration of *M.gilvus* as a starter had changed its color to blackish brown (score 5) in the fourth week, while the color of the compost from other treatments was still brown (score 3) at 0% and 30% concentration, and dark brown (score 4) at 40% concentration). According to Desrihastuti et al. (2019), The color of the compost gradually changes from brown to blackish brown and this is an indication of compost maturity.

The brown to black color is caused by hot conditions due to microbial activity that works during the decomposition process (Nurweni et al., 2019). The addition of termite gut bacteria starter in the decomposition process serves to accelerate the decomposition of compost raw materials. The results showed that the addition of termite gut bacteria starter made the composting process more optimal and produced a blackish brown color.

Smell

Score 1 compost smell is like the original smell, score 2 compost smell is strong pungent, score 3 compost smell is not too pungent, score 4 compost smells like soil, and score 5 compost smells good soil. Changes in odor in compost starting from the smell of material to smelling like soil are expressed in the form of a score which can be seen in Table 4. The average odor score showed that the compost in the fourth and fifth weeks was not significantly different between treatments with the addition of *M.gilvus* bacteria starter at concentrations of 40% and 50% and a concentration of 30% in the fifth week because it had an earthy odor (score 5). In the control treatment (0% concentration of starter bacteria) the smell of the compost was significantly different from the non-control treatment group. This indicates that the concentration of starter termite bacteria *M.gilvus* has an effect on odor in the compost yield.

This happens because there are more bacteria in the composting process and work actively so it speeds up the composting time (Sarkar & Chourasia, 2017). Changes in the smell of compost indicate that the microorganisms present in the composting process can to break down nitrogen bonds in the form of ammonia into free nitrogen which is used as a constituent of microbial body proteins (Fadhila, 2021). The pungent odor of the compost will decrease after the degradation process of the compost material. The state of the compost that has a non-stinging odor and smells like soil indicates that the decomposition process has been completed or the compost has matured (Firdaus et al., 2018).

The Effect of Environmental Factors on the Composting Process

Temperature

Based on the results of temperature measurements, the four composting treatments added starter of termite bacteria *M.gilvus* did not show a significant difference in temperature results ranging from 28.33˚C-30.58˚C. This happens because of the compost reversal treatment so that the temperature can be controlled. These results are in accordance with previous studies which stated that microorganisms that play a role in the active composting process work at a temperature of 25˚C-40˚C (Dewilda et al., 2021).

Based on the standard of SNI 19-7030-2004, the maximum temperature of compost is like that of groundwater, which is not more than 30°C (SNI, 2004). This shows that the composting temperature of each compost treatment has met the standard value.

Degree of Acidity (pH)

Based on the results of the study, the average pH of the compost in each treatment was 5.6-7.0. This result has complied with SNI 19-7030-2004 where good compost must have a degree of acidity (pH) ranging from 6.8 to 7.49. In the early stages of the composting process, all samples reached the lowest pH, ranging from 5.6 to 6.8. This indicates that the degradation of the compost material has occurred due to the accumulation of organic acids and CO2, thereby lowering the pH of the compost (Sundberg et al., 2013). Furthermore, the pH in the composting process has increased due to the activity of microorganisms that convert organic acids that have been formed in the previous stage as energy to break down proteins, cellulose, and lignin (Atalia et al., 2015). The pH value will increase and will reach a neutral pH at the end of composting. The neutral degree of acidity (pH), i.e. pH 6-7 at the end of composting, indicates that the compost has matured (Rahim et al., 2020).

Humidity

Moisture is an important factor in the composting process because it can increase the activity of microbial metabolic rate. In this study, the humidity during the composting process was 50.91%-60.08%. The results showed that the compost produced complied with the standard criteria of SNI. Humidity in the composting process should always be kept in the range of 50-60% so that the activity of microorganisms can work optimally (Farumi et al., 2020). If the humidity is less than 50% then the composting process takes longer because the growth and metabolism of microorganisms are disrupted. Humidity that is too high can also inhibit the degradation process of compost material because the air cavity of the compost will be filled with water and result in reduced oxygen availability so that it will cause aerobic microorganisms to die (Larasati & Puspikawati, 2019).

Research on the use of bacteria in termites' intestines to degrade medical mask waste has never been done. Therefore, the results of this study provide an alternative solution for overcoming the problem of medical mask waste in the midst of the Covid-19 pandemic by using biological agents in the form of bacteria from the intestines of the subterranean termite *M. gilvus* Hagen based on its ability to degrade cellulose.

CONCLUSION

The results showed that there was an effect of adding starter bacteria from the intestines of the subterranean termite *M.gilvus* and the length of time of composting on the physical properties (color, smell, and texture) and chemical properties (C-Organic content, total N, and C/N) of the compost. The concentration of starter bacteria 50% and the most optimal length of time in the degradation of good medical mask waste is 5 weeks according to SNI No. 19-7030-2004 standards. The compost results has a blackish brown color, crumb texture, smells like soil, 20.22% C-Organic content, 1.35% total N content, 15.14% C/N content, and 40.05 moisture content. %. The addition of starter bacteria from the intestines of the subterranean termite *M.gilvus* in composting has the potential to be used as an alternative for treating medical mask waste in the future, but further tests are still needed for use on a larger scale.

ACKNOWLEDGMENT

The researchers would like to express their gratitude to the Ministry of Education and Culture of the Republic of Indonesia for their financial support in conducting this study as part of a Competency Research Grand Challenge. No: 165.26.4/UN37/PPK.3.1/2021

REFERENCES

Annisa Nur Aini & Niken, S. (2015). The Roles Of Bacteria In The Guts of Subterranean Termites *Macrotermes gilvus* Hagen As The Biological Agents Of Organic Material Degradation. *International Conference on Mathematics, Science, and Education 2015 (ICMSE 2015)*, *2015*(Icmse), bacteria, Macrotermes gilvus Hagen, degradation, c.

Arinana, A., Aldina, R., Nandika, D., Rauf, A., Harahap, I. S., Sumertajaya, I. M., & Bahtiar, E. T. (2016). *Termite Diversity in Urban Landscape, South Jakarta, Indonesia*. *7*(2), 1–18. https://doi.org/10.3390/insects7020020

Atalia, K. R., Buha, D. M., Bhavsar, K. A., & Shah, N. K. (2015). *A Review on Composting of Municipal Solid Waste*. *9*(5), 20–29. https://doi.org/10.9790/2402-09512029

Barapatre, S., Rastogi, M., Khosla, B., & Nandal, M. (2020). Synergistic effect of fungal consortia and C/N ratio variation on rice straw degradation. *Nature Environment and*

Pollution Technology, *19*(5), 1831–1839. https://doi.org/10.46488/NEPT.2020.v19i05.006

Desrihastuti, Muhamad, I. I., Rahman, R. A., Sahyoga, G., & Gafur, A. (2019). The effect of particle size of empty fruit bunch and ratio of biosludge of pulp and paper on biochemical changes in composting process. *Jurnal Teknologi*, *81*(2), 81–90. https://doi.org/10.11113/jt.v81.13071

Dewilda, Y, Silvia, S., Riantika, M., & Zulkarnaini. (2021). Food Waste Composting with The Addition Of Cow Rumen Using The Takakura Method and Identification of Bacteria that Role in Composting. *IOP Conference Series: Materials Science and Engineering*, *1041*(1), 012028. https://doi.org/10.1088/1757-899x/1041/1/012028

Dewilda, Yommi, Aziz, R., & Hasnureta, H. (2019). The Effect of Compost Raw Materials (Market Waste, Yard Waste, and Cow Rumen) to Quality and Quantity of Compost. *Indonesian Journal of Environmental Management and Sustainability*, *3*(1). https://doi.org/10.26554/ijems.2019.3.4.14-19

Farumi, S. S., Lingkungan, D. K., & Masyarakat, F. K. (2020). Pengaruh aktivator dalam kompos takakura terhadap tanaman cabai. *Preventia: Indonesian Journal of Public Health*, *5*(1), 55–63.

Ghatge, S., Yang, Y., Ahn, J. H., & Hur, H. G. (2020). Biodegradation of polyethylene: a brief review. *Applied Biological Chemistry*, *63*(1), 1–14. https://doi.org/10.1186/s13765-020-00511-3

Hapsoh, Gusmawartati, & Yusuf, M. (2016). Effect Various Combination of Organic Waste on Compost Quality. *Journal of Tropical Soils*, *20*(1), 59–65. https://doi.org/10.5400/jts.2015.v20i1.59-65

Hermawansyah, D., Iresna, F. M., & Rahmat, A. (2021). Analisis Parameter Fisik Kompos Menggunakan Metode Vermikompos Pada Bahan Baku Daun Kering Physical Parameters Analysis of Compost Using Vermicompost Method. *Open Science and Technology (OST)*, *01*(01), 29–36.

Liu, T., Kumar Awasthi, M., Verma, S., Qin, S., Awasthi, S. K., Liu, H., Zhou, Y., & Zhang, Z. (2021). Evaluation of cornstalk as bulking agent on greenhouse gases emission and bacterial community during further composting. *Bioresource Technology*, *340*(August), 125713. https://doi.org/ 10.1016/j.biortech.2021.125713

Liu, W., Huo, R., Xu, J., Liang, S., Li, J., Zhao, T., & Wang, S. (2017). Effects of biochar on nitrogen transformation and heavy metals in sludge composting. *Bioresource Technology*, *235*, 43–49. https://doi.org/10.1016/ j.biortech.2017.03.052

Macias-Corral, M. A., Cueto-Wong, J. A., Morán-Martínez, J., & Reynoso-Cuevas, L. (2019). Effect of different initial C/N ratio of cow manure and straw on microbial quality of compost. *International Journal of Recycling of Organic Waste in Agriculture*, *8*(s1), 357–365. https://doi.org/10.1007/s40093-019-00308-5

Meng, X., Yan, J., Zuo, B., Wang, Y., Yuan, X., & Cui, Z. (2020). Full-scale of composting process of biogas residues from corn stover anaerobic digestion: Physical-chemical, biology parameters and maturity indexes during whole process. *Bioresource Technology*, *302*, 122742. https://doi.org/10.1016/j.biortech.2020.122742

Miao, Y., Niu, Y., Luo, R., Li, Y., Zheng, H., Kuzyakov, Y., Chen, Z., Liu, D., & Ding, W. (2021). Lower microbial carbon use efficiency reduces cellulose-derived carbon retention in soils amended with compost versus mineral fertilizers. *Soil Biology and Biochemistry*, *156*(March). https://doi.org/10.1016/j.soilbio.2021.108227

Rahim, I. R., Harianto, T., & Ihsan, M. (2020). Study of traditional market waste bioremediation in lowland city as materials for making compost and prospects of development. *IOP Conference Series: Earth and Environmental Science*, *419*(1). https://doi.org/10.1088/17551315/419/1/012085

Ren, X., Wang, Q., Awasthi, M. K., Zhao, J., Wang, J., Liu, T., Li, R., & Zhang, Z. (2019). Improvement of cleaner composting production by adding Diatomite: From the nitrogen conservation and greenhouse gas emission. *Bioresource Technology*, *286*, 121377. https://doi.org/10.1016/j.biortech.2019.121377

Sarkar, P., & Chourasia, R. (2017). Bioconversion of organic solid wastes into biofortified compost using a microbial consortium. *International Journal of Recycling of Organic Waste in Agriculture*, *6*(4), 321–334. https://doi.org/10.1007/s40093-017-0180-8

Subekti, N., Susilowati, D., & Bintari, S. H. (2018). The Potential of Microbial Symbionts

Macrotermes gilvus Hagen Termite Gut as Degrading Agents of Cellulose in Bioethanol Production. *Biosaintifika: Journal of Biology & Biology Education*, *10*(2), 395–400. https://doi.org/http://dx.doi.org/10.15294/biosaintifika.v10i2.14965

Subekti, S. (2010). Pengelolaan Sampah Rumah Tangga 3R Berbasis Masyarakat. *Prosiding SNST Fakultas Teknik*, *1*(1), 24-30.

Subekti N., Widiyaningrum., Nurvaizah I., Mar'ah R. (2019). Effective Control of Subterranean Termite Coptotermes curvignathus Using N-Hexane and Ethyl Acetate From Gaharu (*Aquilaria malaccensis*). *Sys Rev Pharm*. 10(2), 31-33 Print ISSN: 0975-8453 E-ISSN: 0976-2779.

Sundberg, C., Yu, D., Franke-Whittle, I., Kauppi, S., Smårs, S., Insam, H., Romantschuk, M., & Jönsson, H. (2013). Effects of pH and microbial composition on odour in food waste composting. *Waste Management*, *33*(1), 204–211. https://doi.org/10.1016/j. wasman. 2012.09.017

Tay, B. Y., Lokesh, B. E., Lee, C. Y., & Sudesh, K. (2010). Polyhydroxyalkanoate (PHA) accumulating bacteria from the gut of higher termite Macrotermes carbonarius (Blattodea: Termitidae). *World Journal of Microbiology and Biotechnology*, *26*(6), 1015–1024. https://doi.org/10.1007/s11274-009-0264-3

Tripathi, A., Kumar, V., Vivekanand, V., & Bose, P. (2020). Case Studies in Chemical and Environmental Engineering Challenges , opportunities and progress in solid waste management during COVID-19 pandemic. *Case Studies in Chemical and Environmental Engineering*, *2*(October), 100060. https://doi.org/10.1016/j.cscee.2020.100060

Trisakti, B., Mhardela, P., Husaini, T., Irvan, & Daimon, H. (2018). Effect of pieces size of Empty Fruit Bunches (EFB) on composting of EFB mixed with activated liquid organic fertilizer. *IOP Conference Series: Materials Science and Engineering*, *309*(1). https://doi.org/10.1088/1757899X/309/1/012093.

Trivana, L., & Pradhana, A. Y. (2017). Optimalisasi Waktu Pengomposan dan Kualitas Pupuk Kandang dari Kotoran Kambing dan Debu Sabut Kelapa dengan Bioaktivator PROMI dan Orgadec. *Jurnal Sain Veteriner*, *35*(1), 136. https://doi.org/10.22146/jsv.29301

WHO (World Health Organization). (2020). *Virtual press conference on COVID-19 – 11 March 2020*. 1–17. https://www.who.int/docs/default-source/coronaviruse/transcripts/who-audio-emergencies-coronavirus-press-conference-full-and-final-11mar2020.pdf

Yu, H., Xie, B., Khan, R., & Shen, G. (2019). The changes in carbon, nitrogen components and humic substances during organic-inorganic aerobic co-composting. *Bioresource Technology*, *271*, 228–235. https://doi.org/10.1016/j. biortech.2018.09.088

Zhu, L., Zhao, Y., Zhang, W., Zhou, H., Chen, X., Li, Y., Wei, D., & Wei, Z. (2019). Roles of bacterial community in the transformation of organic nitrogen toward enhanced bioavailability during composting with different wastes. *Bioresource Technology*, *285*, 121326. https://doi.org/10.1016/j. biortech.2019.121326