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Original Research Article

The Effect of EM4 Addition with *Eisenia foetida* Worms on Compost Characteristics as a Soil Improver

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Abstract
A lot of fish waste is produced by the community, both from the marketing sector and the fisheries sector, which is caught by fishermen. Almost 35% of the fish waste produced is in the form of heads, bones, innards and also fish remains that are not the main catch which are thrown away directly. Vermicomposting is one of method to reduce the amount of fish waste. The adding of livestock manure in vermicomposting will increase the quality of compost. The purpose of this research is to analyze the compost quality with the mixture of fish waste and livestock manure. The results showed that The compost that has the best quality based on SNI 19-7030-2004 is B2 with 45% fish waste, 20% cow dung and 35% sawdust with a dose of EM4 10 ml, which has a final temperature of 29ºC, pH 7, water content 41%, C-organic 19.83%, nitrogen 1.34%, phosphorus 0.36%, potassium 1.15%, and C/N ratio 14.85. Then, after incubating the soil improvement, it was found that the addition of compost can improve the chemical characteristics of the soil according to the dose given. This indicates that compost application can affect soil quality. Soil quality that has C-organic and nitrogen content according to BPT in 2009 is with the addition of a dose of 5.2 grams of vermicompost. The shortcomings of this study are that the phosphorus and potassium levels are too high.

Keywords: C/N ratio; cow dungs; fish waste; vermicomposting

1. Introduction

Fish waste is underutilized by the community both from the marketing sector and the fisheries sector of the fishermen's catch. Almost 35% of the fish waste produced is in the form of heads, bones, offal and also residual fish that are not the main catch that is disposed of directly (Kurniawan et al., 2015). Fish waste contains protein and other nutrients that can be utilized as compost material. The content of nutrients in fish waste includes C-organic of 10.87%, nitrogen of 2.77, and C/N ratio of 3.92. Utilization of fish waste as compost material still requires mixed materials to support a low C/N ratio to comply with SNI 19-7030-2004, which is 10-20.

Organic waste that can support the composting of fish waste is in the form of livestock manure because of its high content of nutrients such as nitrogen (N), phosphorus (P), and potassium (K) needed by plants and soil fertility. One of the livestock manures that can be utilized as compost material is cow manure (Mirwan, 2015). In the preliminary content test results of this study, the C-organic and nitrogen contents of cow manure were 44.18% and 2.25%, respectively, then the C/N ratio was 19.64 so that it could complement the nutrient content in fish waste.

One of the composting methods is the vermicomposting method. Vermicompost method introduce by Gajalakshmi et al, (2001). Vermicompost is compost obtained from the breakdown of organic materials carried out by earthworms. This method is more effective when compared to the traditional composting method which takes around 6 weeks. The vermicomposting method is carried out for 4 weeks. The vermicomposting method relies on the activity of decomposing bacteria, because worm feces (casting) stimulates the growth of the number of decomposing microbes. In addition, vermicompost is a nutrient for soil microorganisms so that with these nutrients soil microorganisms can decompose organic matter faster (Rahmatullah et al., 2013). This method requires bedding as a living medium for earthworms, one of which is sawdust. Sawdust is needed as bedding for earthworms and bulking agent to increase organic matter content in the vermicomposting process (Siswanto et al., 2021). The nutrients contained in sawdust include C-organic at 50.58%, nitrogen at 0.39%, and a C/N ratio equal to 129.69.

Processing organic waste into compost is a very beneficial innovation in several fields, not only in the environmental field, but also in agriculture. Vermicomposting has advantages over traditional composting, including a faster composting process due to the help of earthworms, producing a superior product at a low cost, and being environmentally friendly (Zhou et al., 2021). Therefore, it is hoped that with this innovation, people's insight and sensitivity to waste in the environment can increase. This research aims to determine the quality of compost from vermicomposting that has been carried out by utilizing organic waste found in the surrounding community.

2. Methods

The composting method used in this research is the vermicomposting method. The initial step taken was to test the C-Organic, Nitrogen and initial moisture content of the main ingredients of fish waste, cow manure, and sawdust. This step aims to determine the C/N ratio of the main compost material used to determine the initial C/N ratio of the composting process with variations in the composition of certain materials. The initial characteristics of compost materials can be seen in Table 1.

Table 1. Preliminary characteristics of compost materials

Compost Materials	C-Organic (%)	Nitrogen (%)	C/N Ratio	Moisture Content (%)
Fish Waste (FW)	10.87	2.77	3.92	75.84
Cow Manure (CM)	44.18	2.25	19.64	8.78
Saw Dust (SD)	50.58	0.39	129.69	8.11

After the initial characteristics of the material are obtained, the next step is to determine the initial C/N ratio of composting through the percentage variation in the composition of the compost material. In this study, an initial C/N ratio of 23-70 was used because there was a decrease in the ratio when decomposing the material by earthworms in the composting process (Setiani et al., 2021). The material variations in this study are 45% fish waste, 20% cow manure, and 35% sawdust. The following is the calculation formula used to determine the C/N ratio in equation (1):

$$\frac{C}{N} = \frac{9\ (C\ 1\ kg\ Fish\ Waste) + 4\ (C\ 1\ kg\ Cow\ Manure) + 7\ (C\ 1\ kg\ Saw\ Dust)}{9\ (C\ 1\ kg\ Fish\ Waste) + 4\ (C\ 1\ kg\ Cow\ Manure) + 7\ (C\ 1\ kg\ Saw\ Dust)} \quad (1)$$

$$\frac{C}{N} = \frac{9\ (2.63) + 4\ (40.30) + 7\ (46.48)}{9\ (0.69) + 4\ (2.05) + 7\ (0.36)}$$

C/N = 30 (as the suggested C/N ratio)

Furthermore, making the reactor design through measuring the density of materials based on SNI 19-3964-1994 in order to determine the volume of compost needed. After the calculation process, the total initial compost material requirement is 12 kg per reactor. The reactor used is a continous flow bin type reactor to support oxygen supply in compost made from wood because it is more economical and easy to shape as needed (Kusuma, 2018). The dimensions of the reactor used for composting are 50 cm x 45 cm x 15 cm. The reactor design can be seen in Figure 1.

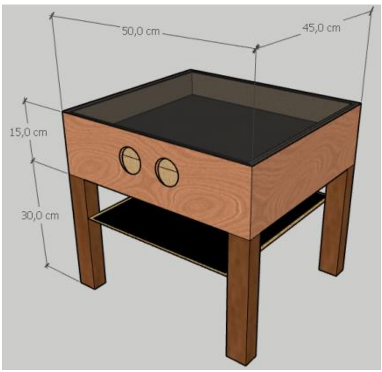


Figure 1. Design of vermicomposting reactor

Before being put into the reactor, the large compost material is chopped first to make the size of the material smaller. Then, the compost material is mixed according to the percentage of material variation that has been determined. In this study, variations in the dose of EM4 addition were also used, namely 0 ml, 10 ml, and 15 ml for every 1 kg of compost material. EM4 that are used in this research is the EM4 for agriculture. Table 2 below is the result of determining the variation of material composition and EM4 for each reactor.

Table 2. Compost material composition and EM4 dosage

No.	EM4 Doses	Compost Material 45%Li+20%KS+35% SG
1.	0 ml	B1
2.	10 ml	B2
3.	15 ml	B3

The next step is the pre-vermicomposting stage. Pre-vermicomposting is the process of initial decomposition of compost materials so that these materials pass through the thermophilic phase and are in accordance with the ability of worms to adapt to pH 7.5-8, temperature 15-25^{o}C, and humidity 60-70%. (Rahmatullah et al., 2013). The monitoring of pH, temperature, and moisture content of the compost material was carried out using a soil anayxer tester and soil moisture tester. The pre-vermicomposting stage was carried out for 14 days to give the materials time to ferment naturally (Zen et al., 2022). This is done to remove toxic substances in order to facilitate the decomposition process of materials and easily digested by worms during composting (Cai et al., 2020).

After the pre-vermicomposting stage, the worm acclimatization stage was continued. This stage is carried out for 2x24 hours by inserting worms in compost material with the aim of giving worms time to adapt to compost media (Prayogo et al., 2016). This is followed by the vermicomposting stage for 2 weeks.

During the compost harvesting period, the compost material was sieved with a 2.5 mm diameter sieve so that the particle size of the compost was in accordance with SNI 19-7030-2004. Then, the compost was tested in the laboratory to determine the chemical content of the compost, including C-organic, nitrogen, phosphorus, and potassium. Measurement of C-organic content was carried out using the gravimetric method. Nitrogen content was measured using the Kjeldahl method. Phosphorus content was measured using the spectrophotometric method. Potassium content was measured using the AAS (Atomic Absorption Spectrophotometry) method. Then, MANOVA statistical test was conducted to determine the effect of EM4 dosage on compost chemical parameters and Taguchi test to obtain the best compost variation to be used as a soil conditioner.

The critical soil incubation process aims to improve the soil by adding compost products with certain dose variations anaerobically. The soil incubation process was carried out for 14 days with variations in the dose of adding 0 gr of vermicompost, 2.6 gr of vermicompost, 5.2 gr of vermicompost by mixing it evenly (Siregar, 2023). Soil incubation samples based on the dose of compost applied can be seen in Table 3.

Table 3 Variations in compost dosage for soil improvement

Variation	Result Compost Vermicomposting B2 45%Li+20%KS+35% SG + Eisenia fetida 15 gr/kg
S0	0 gr compost/500 gr critical soil
S1	2.6 gr compost/500 gr critical soil
S2	5.2 gr compost/500 gr critical soil

Then, chemical characteristics of the soil were tested after incubation. C-organic content was tested using spectrophotometric method. Nitrogen content was tested using the spectrophotometric method. Phosphorus content was tested using the spectrophotometric method. Potassium content was tested using the AAS (Atomic Absorption Spectrophotometry) method. Then followed by analysis and discussion of the research.

3. Result and Discussion

During composting, organic materials in the form of fish waste, sawdust, and cow manure are placed in the reactor with a predetermined percentage composition, temperature monitoring is carried out.

3.1. Temperature

In this study, temperature measurements were taken every day to determine the temperature conditions of the compost according to the needs of earthworms as a medium. The temperature monitoring graph of compost material in each reactor during the composting process can be seen in Figure 2.

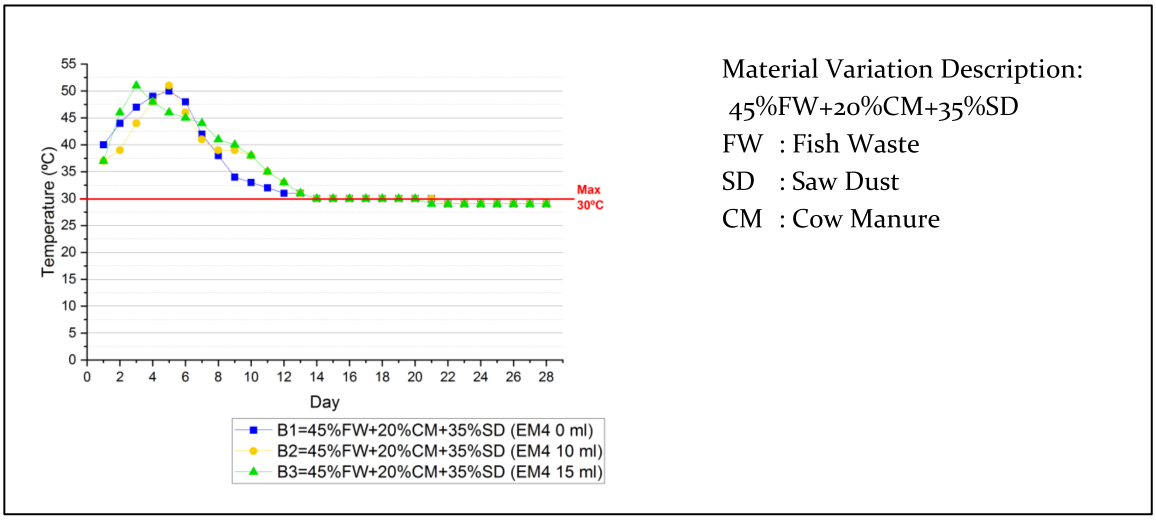


Figure 2. Temperature graphic

Figure 1 is the temperature observation data in each reactor during the composting process. The compost material experiences an increase in temperature from the mesophilic phase until it reaches the highest point around 45-60ºC or called the thermophilic phase (Mufti et al, 2021). Figure 1 shows that the compost material that was given an additional dose of EM4 experienced the highest temperature increase compared to that without EM4. This is because there is an increase in the activity of microorganisms in decomposing compost materials. In B2 (10 ml EM4 dosage), the compost temperature experienced the highest increase on the 5th day. Meanwhile, in B3 (15 ml EM4 dosage), the compost temperature experienced the highest increase faster on day 3 due to the greater number of microorganisms that were active. This indicates that the volume of EM4 dose can affect the rate of increase in compost temperature because microorganisms will convert organic compounds such as organic carbon, into CO2 gas, water vapor, and heat (Subula et al, 2022). Then, the compost temperature of each reactor decreased back to the mesophilic phase until it stabilized around 28-30ºC. This is due to the maturation of compost and a decrease in the decomposition process of materials (Suhartini et al., 2020).

3.2. pH

In this study, pH measurements were taken every day to adjust to the pH conditions of the compost needed by earthworms as a medium. The pH monitoring graph of compost material in each reactor during the composting process can be seen in Figure 3.

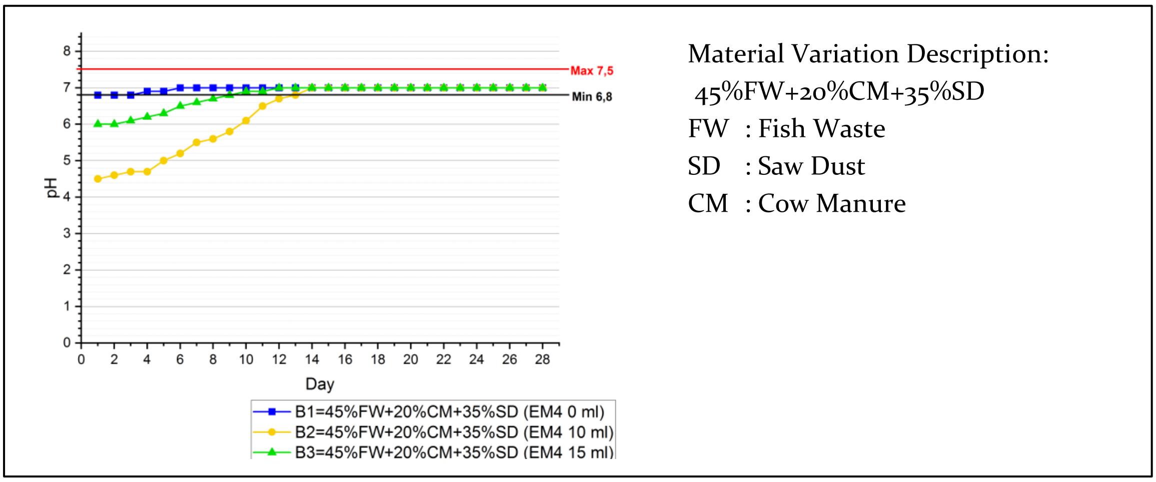
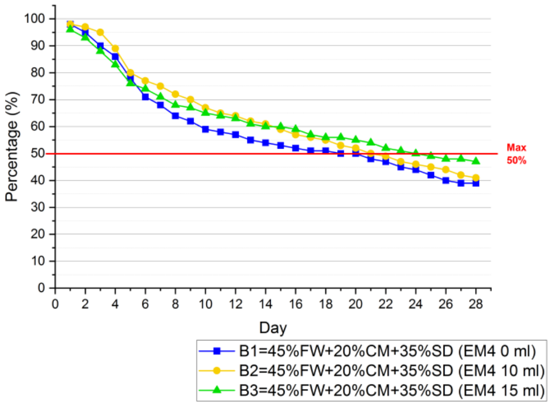


Figure 3. pH graphic

Figure 3 shows an increase in pH at the pre-vermicomposting stage or the initial fermentation process. Reactor B2 has a very acidic initial pH compared to other reactors. This is because EM4 contains acidic pH and microorganisms are still not working optimally at this dose (Siswati et al., 2009). The increase in pH that occurs in graphs B1, B2, and B3 is caused by the breakdown of protein into ammonia (NH3). The change in compost pH starts with a slightly acidic pH due to the formation of simple organic acids, then the pH increases during further composting process due to protein degradation and ammonia release (Widarti et al., 2015). The stable pH of compost during the maturation period indicates that the microorganisms that decompose the material work optimally so that the pH of the compost meets the quality standards of SNI 19-7030-2004, which ranges between 6.8 and 7.49 (Widiyaningrum & Lisdiana, 2015).

3.3. Moisture Content

Measurement of moisture content is taken daily using a soil moisture tester. pH monitoring graph of vermicompost in each reactor can be seen in Figure 4. Figure 4 shows that there is a decrease in water content in reactors B1, B2, and B3 caused by the release of water from wasted organic matter and the evaporation process due to an increase in compost temperature from microorganism activity that occurs in each compost pile (Kusdiana et al, 2019). The moisture content of the compost material can affect the microbial metabolic process and indirectly affect the oxygen supply. In the early stages of composting, microorganisms are very active in absorbing organic matter, and this decomposition process produces liquid (leachate) (Widarti et al, 2015). However, in this study, porous sawdust is used so that it plays a role in absorbing excess water or leachate water produced during composting so that there is no fluctuation in the decrease in water content in each reactor. The nature of the sawdust can make it easier for earthworms to breed and survive (Rahmawati, 2017).



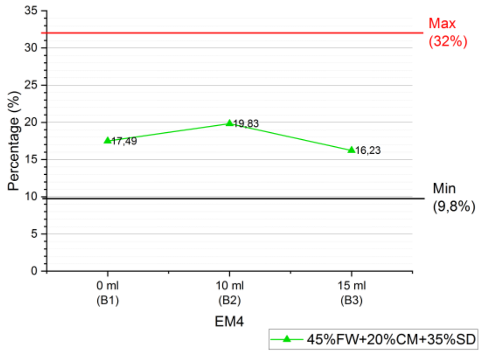
Material Variation Description:
45%FW+20%CM+35%SD
FW : Fish Waste
SD : Saw Dust
CM : Cow Manure

Figure 4. Moisture content graphic

3.4. CNPK

3.4.1 C-Organic

The graph of compost C-organic content can be seen in Figure 5.



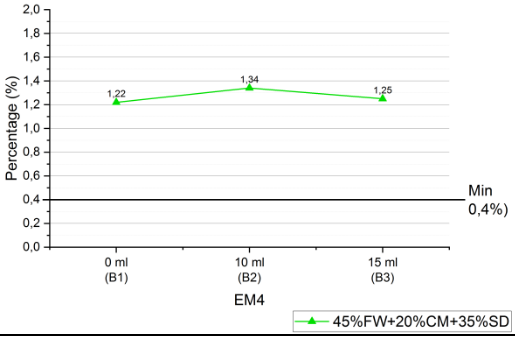
Material Variation Description:

FW : Fish Waste
SD : Saw Dust
CM : Cow Manure

Figure 5 C-organic graphic

Figure 5 shows that reactor B2 has the highest C-organic content compared to other reactors, while B3 has the lowest C-organic content. The high C-organic content in B2 indicates that the dose of 10 ml EM4 degrades organic matter more optimally. The process of forming C-Organic vermicompost is due to the degradation process of materials assisted by Eisenia foetida worms and microorganisms in the material. The process has respiration and assimilation of microorganisms and worms that convert available organic C into CO_2 gas (Suthar and Gairola, 2014). The decrease in C-organic content is due to the release of carbon in the compost material, this is because the mature compost material is still undergoing continuous decomposition (Purnomo et al, 2017).

3.4.2 Nitrogen



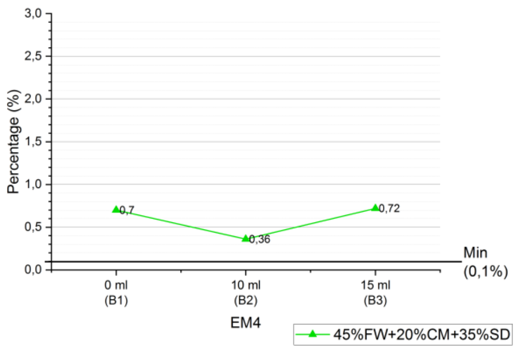
Material Variation Description:

FW : Fish Waste
SD : Saw Dust
CM : Cow Manure

Figure 6. Nitrogen graphic

Figure 6 shows that reactor B2 has the highest nitrogen levels compared to other reactors. In the fermentation process of compost material, N compounds become nutrients for bacteria. This is because microorganisms need a certain amount of nitrogen to maintain and form body cells. The more nitrogen, the faster organic matter decomposes, because microorganisms that decompose compost materials need nitrogen to develop (Purnomo et al, 2017). Figure 6 means that B2 has the highest nitrogen level so that in this reactor the decomposition of organic matter occurs faster than other reactors. Composted fish waste and cow manure as substrates provide good conditions for earthworms and microorganisms thereby enhancing nitrification and/or nitrogen mineralization (Li et al., 2020).

3.4.3 Phosphor



Material Variation Description:

FW : Fish Waste
SD : Saw Dust
CM : Cow Manure

Figure 7. Phosfor graphic

Figure 7 shows that the highest phosphorus content was found in reactor B3 and the lowest in B2. However, the phosphorus content of each reactor still meets the quality standards of SNI 19-7030-2004 which is more than 0.1%. The phosphorus content of B2 means that there is more utilization of organic matter by worms and microorganisms than B1 and B3. The phosphorus content of compost depends on the initial substrate contained in the compost material. The high and low phosphorus content is caused by microbial activity when the compost material is ingested while passing through the worm's digestive tract which results in phosphorus enrichment (Li et al., 2020). The milled fish waste material consists of a mixture of fish heads, fins, bones, and fish innards which contain phosphorus levels of 13.5%, supporting the increase in phosphorus levels of the compost produced (Ibrahim et al 2013). The vermicomposting method is an efficient method of converting unavailable P content into available P with the help of P-solubilizing microorganisms through phosphate digestion in the worm's gut (Bhat et al 2016).

3.4.4 Potassium

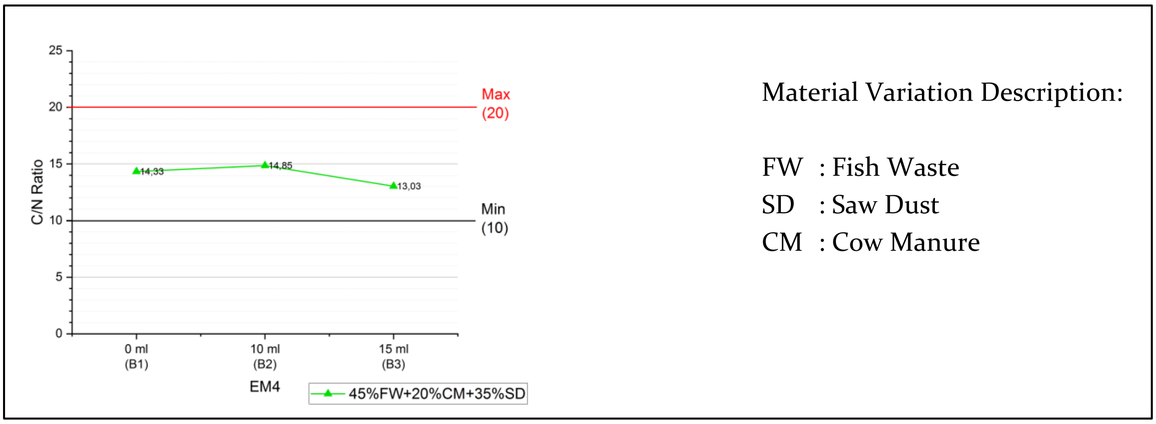


Figure 8. Potassium graphic

Figure 8 shows that the potassium content of reactor B2 is the highest and B3 is the lowest. Each reactor has potassium content still in accordance with the quality standards of compost based on SNI 19-7030-2004, which is at least 0.2. This increase is caused by two factors, the first is weathering that releases K+ ions from the cation exchange site and the second is the decomposition of organic matter during the composting process. Potassium is used by microorganisms to encourage bacteria in the substrate, and their activity affects the increase of potassium in the soil (Magfirah, 2021). The increase in potassium can be attributed to the production of acid during the degradation of organic compounds by microorganisms while converting the insoluble potassium content in the mixture into a soluble form so that in reactor B3 there is more evaporation of potassium content. Potassium content is directly linked to enzymes such as phosphatase present in the digestive system of earthworms and bacterial activity (Alavi et al., 2017).

3.4.5 C/N Ratio

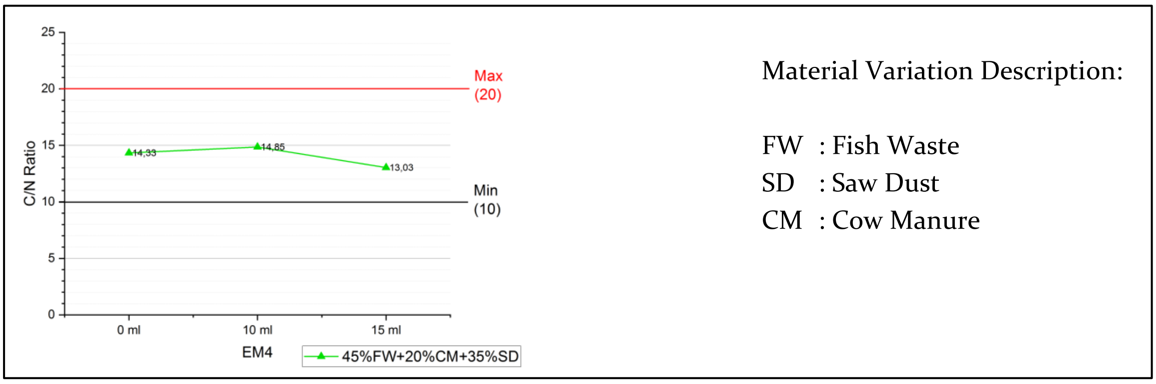


Figure 9. CN ratio graphic

Figure 9 shows that reactor B2 has the highest C/N ratio compared to the other reactors. A high C/N ratio in compost can cause the concentration of nitrogen elements to decrease due to the activity of microorganisms that tend to consume nitrogen during their growth period. An important factor in the decomposition process is the C/N ratio. This not only contributes to the quality of organic fertilizer, but is also an indicator of the maturity of the organic fertilizer itself. If the C/N ratio is lower, the decomposition process will be faster. This is done to accelerate composting and is caused by the temperature of the C/N ratio material (Wulansari et al, 2020). The presence of C and N elements improves the quality of vermicast and is needed for organic matter input to the soil. In a pinch, worms will consume vermicast because there is still adequate C-organic content available (Soma, 2018).

3.4.6 Statistical Analysis

The results of statistical analysis to determine the effect of EM4 dose on vermicompost quality include normality, homogeneity, and MANOVA tests can be seen in Table 4.

Table 4 Statistical Test Results of Normality, Homogeneity, and MANOVA

Normality Test				
Parameters	**P-Value**	**Description**	**Normality**	**Method**
C-organic	0.672	P-Value > 0.05		Shapiro-Wilk
Nitrogen	0.463	P-Value > 0.05	Normal data	Shapiro-Wilk
Phosfor	0.094	P-Value > 0.05	Normal data	Shapiro-Wilk
Kalium	0.391	P-Value > 0.05	Normal data	Shapiro-Wilk
CN Rasio	0.537	P-Value > 0.05	Normal data	Shapiro-Wilk
pH	0.510	P-Value > 0.05	Normal data	Shapiro-Wilk
Temperature	0.233	P-Value > 0.05	Normal data	Shapiro-Wilk
Moisture Content	0.463	P-Value > 0.05	Normal data	Shapiro-Wilk
Homogenity Test				
Parameter	**P-Value**	**Description**	**Homogenity**	**Method**
C-organic	0.181	P-Value > 0.05	Homogeneous data	Levene
Nitrogen	0.207	P-Value > 0.05	Homogeneous data	Levene
Phosfor	0.073	P-Value > 0.05	Homogeneous data	Levene
Kalium	0.055	P-Value > 0.05	Homogeneous data	Levene
CN Rasio	0.511	P-Value > 0.05	Homogeneous data	Levene
pH	0.478	P-Value > 0.05	Homogeneous data	Levene
Temperature	0.172	P-Value > 0.05	Homogeneous data	Levene
Moisture Content	0.427	P-Value > 0.05	Homogeneous data	Levene
MANOVA Test				
Parameter	**F**	**Sig**	**Hypothesis**	**Description**
C-organic	418.95	0.000	H1 accepted	Affect
Nitrogen	92.39	0.000	H1 accepted	Affect
Phosfor	5.31	0.005	H1 accepted	Affect
Kalium	10.46	0.014	H1 accepted	Affect
CN Rasio	64.98	0.000	H1 accepted	Affect
pH	2700.48	0.000	H1 accepted	Affect
Temperature	1648.75	0.000	H1 accepted	Affect
Moisture Content	394.65	0.000	H1 accepted	Affect

The results of the normality test on compost characteristics resulted in a P-Value> 0.05 using the Shapiro-Wilk method because the data sample was less than 50. Table 4 shows that the P-Value> 0.05 indicates that the compost quality test data has a normal data distribution pattern (Quraisy, 2022). Then, a MANOVA statistical test was conducted to determine whether or not the independent variable had an effect on the dependent variable of the study (Savitri et al., 2021). Based on the results of the MANOVA test, the significance value of all parameters was <0.05, indicating that the variation in EM4 dosage had a significant effect on all compost parameters.

The variation of EM4 doses affects the C-organic content of vermicompost because EM4 triggers an increase in the activity of microorganisms in decomposing the substrate and reducing the amount of carbon in the substrate. The activity of earthworms and microorganisms from EM4 causes the release of carbon in the form of CO_2 (Usmani et al., 2017).

The addition of different doses of EM4 can affect the nitrogen content of the compost produced. The greater the amount of EM4 added, it can increase the activity of microorganisms to grow and carry out the nitrogen nitrification process. The process of converting ammonia nitrogen into nitrite through nitrification can increase the nitrogen content of vermicompost (Aryonugroho & Lestari, 2021).

The variation of EM4 dosage has a significant effect on the phosphorus content of vermicompost at the end of composting. The addition of EM4 at a certain dose can increase the activity of microorganisms in breaking down organic matter into simpler ones. This triggers phosphate-solubilizing microorganisms from compost materials to decompose phosphate from raw materials naturally by secreting organic acids and producing phosphate ions so that the phosphorus content of compost increases (Himawarni & Nuraini, 2022).

The addition of EM4 significantly influenced the potassium content of the compost due to the significance value<0.05 obtained from the MANOVA test. This indicates that the addition of EM4 at a certain dose can potentially increase the activity of microorganisms in decomposing compost materials and forming potassium elements optimally (Lakaoni et al., 2022).

The addition of various doses of EM4 has a significant effect on the CN ratio of compost. This is because EM4 supplies a number of microorganisms that play a role in decomposing compost materials. Microorganisms break down the carbon element in the form of CO_2 by requiring nitrogen to form body cells and develop (Purnomo et al., 2017).

The addition of various doses of EM4 has a significant effect on compost pH. This is because a number of EM4 microorganisms can accelerate the increase in compost pH during composting. The activity of microorganisms in protein breakdown and ammonia release causes an increase in compost pH until it stabilizes at a neutral pH (Widarti et al., 2015).

3.5. Land Improvement

The incubation process of soil with vermicompost was carried out to give time for vermicompost to perform its role as an improvement in soil quality structure. The doses used in this study include 0 gr vermicompost, 2.6 gr vermicompost, 5.2 gr vermicompost. Then the results of the chemical characteristics test can be seen in Table 5.

Table 5. Soil chemical parameter test results compared to BPT standards

Parameters	**Preliminary Soil**	**Final Land**			**BPT Standards**				
		So 0 gr compost/500 gr critical soil	**S1 2,6 gr compost/500 gr critical soil**	**S2 5,2 gr compost/500 gr critical soil**	**VL**	**L**	**M**	**H**	**VH**
C-organic	0.48	0.46	1.44	2.75	< 1.0	1.0 - 2.0	2.0 - 3.3	3.3 - 5.0	> 5.0
N-Total	0.06	0.03	0.07	0.21	< 0.1	0.1 - 0.2	0.2 - 0.5	0.5 - 0.75	> 0.75
Phosfor	48.9	59.74	120.89	309.34	< 10	10 - 20	20 - 40	40 - 60	>60
K-Total	43.19	38.14	52.08	103.90	< 10	10 - 20	20 - 40	40 - 60	>60
pH (VA<4,5)	6.79	7	7.1	7.3	**Ac.**	**QA**	**N** 6.	**SA** 7.6	**A**

Para-meters	Prelimi-nary Soil	Final Land			BPT Standards				
		So 0 gr compost/500 gr critical soil	S1 2,6 gr compost/500 gr critical soil	S2 5,2 gr compost/500 gr critical soil	VL	L	M	H	VH
					4.5 - 5.5	5.6 - 6.5	6 - 7.5	- 8.5	>8. 5

Note:

VL: Very Low
L: Low
M: Medium
H: High
VH: Very High
VA: Very Acid
Ac: Acid
QA: Quaited Acid
N: Neutral
SA: Sightly Alkaline
A: Alkaline

The test results of C-organic content in the soil showed that S2 contained the highest C-organic content among the 3 samples, this indicates that the greater the dose of vermicompost given, the higher the C-organic content contained in the soil. The increase in C-organic levels in the soil is due to the process of decomposing carbon levels in the soil by compost microbes and the death of compost microorganisms that decompose so that they blend with the soil (Nurhasanah, 2020).

The test results of N-Total levels in the soil showed that S2 contained the highest N-Total among the 3 samples, this indicates that the greater the dose of vermicompost given, the higher the N-Total levels contained in the soil. In the control soil sample, the decrease in N-Total levels indicates evaporation and nitrogen utilization by soil microbes during incubation. Meanwhile, the increase in N-Total contained in the vermicompost application is due to the result of the mineralization process that releases N-organic, ammonium, and nitrate in the soil carried out by microorganisms (Affandi, 2018).

The test results of phosphorus levels in the soil show that S2 contains the highest phosphorus among the 3 samples, this indicates that the greater the dose of vermicompost given, the higher the phosphorus levels contained in the soil. The dose of vermicompost given can neutralize aluminum and iron levels in the soil. This can cause the available phosphorus content in the soil to increase and the phosphorus fixation process to decrease (Rohim et al., 2012). The increase in soil phosphorus comes from the weathering process of organic matter that produces humic acids and fulates that decompose P from the sorption complex (Sholeha, 2018).

The results of the soil potassium content test show that S2 contains the highest potassium among the 3 samples, this indicates that the greater the dose of vermicompost given, the higher the phosphorus content contained in the soil. The control soil sample experienced a decrease in potassium levels, which indicates that there is a degradation of potassium content in the soil every day when not given compost. Meanwhile, the increase in soil K-Total levels comes from the breakdown of soil organic matter and vermicompost which releases nutrients that are useful for increasing soil nutrients (Pamungkas et al., 2016).

The results of soil pH observations during the incubation process of soil improvement obtained that S2 experienced the highest pH increase among the 3 samples, this indicates that the dose of vermicompost added can affect the increase in pH. The increase in pH is due to the exchange of basic cations such as calcium from vermicompost materials with soil colloids that absorb many organic acids such as humic acid. The cation exchange reaction occurs calcium adsorption which causes soil pH to rise until it reaches the neutral pH category according to the Soil Research Center of the Soil Department in 2009 (Purba et al., 2017).

4. Conclusions

The compost that has the best quality based on SNI 19-7030-2004 is B2 with 45% fish waste, 20% cow dung and 35% sawdust with a dose of EM4 10 ml, which has a final temperature of 29ºC, pH 7, water content 41%, C-organic 19.83%, nitrogen 1.34%, phosphorus 0.36%, potassium 1.15%, and CN ratio 14.85. Then, after incubating the soil improvement, it was found that the addition of compost can improve the chemical characteristics of the soil according to the dose given. This indicates that compost application can affect soil quality. Soil quality that has C-organic and nitrogen content according to BPT in 2009 is with the addition of a dose of 5.2 grams of vermicompost. The shortcomings of this study are that the phosphorus and potassium levels are too high. Suggestions for further research are to change compost materials that have sufficient phosphorus and potassium levels as soil improvers.

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