JURNAL TEKNIK SIPIL DAN LINGKUNGAN| EISSN:2549-1407
https://jurnal.ipb.ac.id/index.php/jsil

Vol. 10 No. 01 April 2025
DOI: 10.29244/jsil.10.1.149-158

Potential Composting Paper and Food Waste using Cow Rumen Bioactivator at IPB University Dramaga Campus

Alda Hesti Yulianti and Joana Febrita*

Department of Civil and Environmental Engineering, IPB University, Bogor, 16680, Indonesia
*Corresponding author: joanafebrita@apps.ipb.ac.id

Abstract: Educational institutions, including IPB University Dramaga, generate paper and food waste. Waste paper reached 679.84 kg per day, and food waste reached 379.55 kg/day. Both are collected at Taman Semangat located in Cikabayan IPB Dramaga and have the potential to pollute the environment if not treated further. However, IPB has the potential of cattle rumen that has not been effectively utilized. One of the waste treatments that can be performed is composting. This study aimed to analyze the characteristics and quality of compost, determine the best compost variation, and analyze the potential of composting in reducing paper and food waste at IPB Dramaga Campus. Composting was performed by mixing waste paper and food waste using a cow rumen bioactivator. Composting was carried out for 8 weeks aerobically using two composting methods, namely open windrow and aerated static pile (ASP). The results showed that compost characteristics including color, volume, temperature, moisture content, pH, C-Organic, N-Total and C/N ratio were in accordance with SNI 19-7030-2004. Compost that was in accordance with the standard was found in variations A3 and B3 after four weeks. In this variation, the weight ratio of waste paper to food waste and cow rumen is 1.75: 5: 3,25. This composting variation was able to reduce waste paper and food waste based on variations A3 and B3 by 67% and 13%.

Submitted: 27 Feb 2025
Revised: 14 Apr 2025
Accepted: 17 Apr 2025

Keywords: compost; cow rumen; food waste; waste paper

1. Introduction

Paper is one of the most common types of waste generated by humans, both in educational institutions and offices. One of the main sources of waste paper generation is educational institutions, as almost all activities are directly related to the use of paper [1]. The use of paper in educational institutions is necessary, such as for assignments by teachers, recording learning materials, and making questions and exam answer papers [2]. This is experienced by educational institutions, including the IPB. The type of waste other than paper generated by IPB Dramaga Campus is organic solid waste, such as food waste. The Taman Semangat IPB Cikabayan team manages the solid waste generated by the IPB Dramaga Campus. The activities carried out are collection, transportation, and processing. Solid waste treatment is only carried out on certain solid wastes, such as leaf/grass, which is treated into compost, and inorganic solid waste, such as Styrofoam, into paving blocks. However, in general, waste paper and food waste are only collected at the IPB sorting house without being treated before being transported to the Landfill, TPA Galuga.

The Sustainable Campus Development Board (BPKB) of IPB in 2023 has measured the solid waste generation at IPB Dramaga Campus in accordance with

SNI 19-3964-1994. The results showed that the total solid waste generated on campus reached 1751.47 kg per day (1.75 tons per day). Waste paper accounted for 39% of the total waste generated, weighing 679.84 kg per day (0.68 tons per day). Food waste accounts for 22% of the total waste generated, which is 379.55 kg per day (0.38 tons per day). Universities such as IPB are required to be active in preserving the environment, especially in waste management and solid waste [3]. Referring to the applicable laws and regulations, namely UU No. 23 1997 concerning environmental management, the waste generated should be managed and utilized, followed by pollution control and degradation of environmental quality and natural resources. Composting is a waste processing or utilization method suitable for organic waste, such as food waste.

Composting, according to SNI 19-7030-2004, is the process of decomposing organic matter into compost. Food waste is used as a compost material because of its high organic content and low heavy metal content [4]. Waste paper, which is rich in carbon sources, requires additional nitrogen sources, such as food waste, to achieve an ideal C/N ratio. In addition, cow rumen bioactivator produced from the IPB abattoir was used. One of the nutrient-rich slaughterhouse wastes is cow rumen contents, which are obtained from slaughterhouse facilities [5]. The waste of cow rumen contents generated from the abattoir Faculty of Animal Science IPB Dramaga Campus amounted to 455 kg or 13 bags of rumen per slaughtering, which was collected at the waste disposal site and then disposed of. Cattle rumen waste has great potential as a fertilizer because of its high nutrient content [6].

One processing method that can be used is composting, such as the open windrow and aerated static pile methods [7]. The composting process with These methods were chosen because they are more efficient than conventional methods, which tend to rely on natural decomposition processes without optimal control of environmental factors such as aeration, humidity, and temperature. This composting process utilizes materials that are easily available at IPB Dramaga Campus, such as waste paper, food waste, and cow rumen from the slaughterhouse of IPB Dramaga Campus. The use of these materials has the potential to accelerate the composting process, thus enabling the production of the highest quality compost through two composting methods that produce compost with characteristics and quality in accordance with the SNI 19-7030-2004 standards. Composting is also an efficient method for reducing waste volume, so composting paper and food waste at IPB Dramaga Campus has great potential to significantly reduce paper and food waste. Therefore, this study aimed to analyze the characteristics and quality of compost, determine the best compost variation, and analyze the potential of composting in reducing paper and food waste at IPB University Dramaga Campus.

2. Materials and Methods

2.1 Materials

The tools and materials used in this research were divided into two categories: those used for making compost and those used for testing compost characteristics. The tools used for composting included a wooden compost box, wire mesh as a cover for the compost box, blower, pipe, soil fork, digital hanging scale, bucket, sprayer, 50 cm ruler, soil thermometer, soil pH meter, and compost chopper. Tools used in the laboratory included digital scales, cups, ovens, electric heaters, desilator units, Kjeldahl flasks, burettes, Erlenmeyers, volumetric pipettes, ball pipettes, measuring cups, measuring flasks, spectrophotometers, cuvettes, and laptops with Microsoft Excel installed. The materials used to make compost were waste paper and food waste from IPB Dramaga Campus, water, cow rumen from the slaughterhouse of IPB Dramaga Campus, and phosphate buffer pH 7. The materials used in the laboratory were sulfuric acid (H_2SO_4), sodium thiosulfate ($Na_2S_2O_3$), 0.05 N H_2SO_4 standard solution, boric acid, Conway indicator, sodium hydroxide (NaOH), potassium bicarbonate ($K_2Cr_2O_7$), glucose, and ion-free water.

2.2 Research Procedures

Research-related procedures included literature study, preparation of tools and materials, mixing of compost materials, composting process, observation and analysis of compost characteristics, comparing the quality of compost results with SNI 19-7030-2004, and calculating the reduction potential of paper and food waste at IPB Dramaga Campus.

The wooden compost box, measuring 40 × 40 × 35 cm, has a capacity of 10 kg of compost material. The box was equipped with a wooden cover with a wire mesh in the center and 5 cm high legs at the bottom, whereas the aerated static pile composting method added a small pipe and blower at the bottom of the box for air circulation. Cow rumen fluid was obtained from the abattoir of the IPB Dramaga Campus. Cow rumen was squeezed and filtered [8], and the liquid was stored in gallons, phosphate buffer pH 7 was added in a ratio of 1:1, and then fermented for one week. The remaining rumen was used as a mixture of composting material. The waste paper was soaked in distilled water for 3 days, and the food waste was cut into small pieces of approximately 2 cm in size.

Composting was conducted for eight weeks using aerobic methods, namely the open windrow and aerated static pile methods. Compost was made with a basic material composition consisting of waste paper, food waste and cow rumen in the ratio of 3:5:2. This study included six variations made in duplicate, where three variations used the open windrow method and the other three used the aerated static pile method, as presented in **Table 1**. The compost materials were chopped, mixed, and piled to a thickness of ±15 cm, followed by the application of a bioactivator liquid made with a 1:1 dosage ratio of cow rumen liquid and phosphate buffer pH 7 that had been dissolved in water and allowed to stand for one week before use.

Table 1. Variations of compost material

Variations	Materials (kg)			
	Waste Paper	Food Waste	Cow Rumen	Method
A1	3.25	5	1.75	Open Windrow
A2	2.5	5	2.5	
A3	1.75	5	3.25	
B1	3.25	5	1.75	Aerated Static Pile
B2	2.5	5	2.5	
B3	1.75	5	3.25	

The characteristics observed during the composting process are physical characteristics in accordance with SNI 19-7030-2004. The physical characteristics observed were temperature, pH, color, and height of the plants. Observations were made daily. Compost temperature and pH were measured using a soil thermometer and soil pH meter, respectively. Compost volume shrinkage was calculated by observing changes in the height of the compost pile, measured using a ruler inserted into the pile from the beginning to the end of the observation. Changes in compost color were observed using the sense of sight. Laboratory tests were conducted to evaluate compost characteristics, such as moisture content, carbon content, nitrogen content, and C/N ratio, with reference to SNI 7763:2018. Testing was conducted nine times between weeks 0 and 8.

3. Result and Discussion

3.1 Composting

Composting was carried out for two months, from May to July 2024. The composting process was carried out in a cube-shaped box measuring 40 × 40 × 35 cm, made of teakblock wood with a thickness of 18 mm, and equipped with 5 cm high legs at the bottom of the box. The top of the box was covered with a wire mesh in the center to maintain aerobic conditions. The open system composting process includes open windrows and aerated static piles [9]. The composting sites for each method are shown in **Figure 1**.

Figure 1. Open windrow and aerated static pile composting bins

3.2 Preliminary Test of Compost Materials

The preliminary stage of the compost material was carried out before starting the composting process. Based on the preliminary test results of the compost material characteristics (**Table 2**), waste paper had the lowest water content. Waste paper has a high water absorption capacity. Food waste has the highest moisture content after cow rumen, because waste derived from food waste still contains high moisture content [10]. Cow rumen waste also has a high moisture content after food waste, which is due to the high moisture content in the cow's rumen after the digestive process of food waste. The moisture content of the three compost raw materials was in accordance with SNI 19-7030-2004, which is ≤50%.

Table 2. Preliminary test results of compost material characteristics

Parameters	Materials		
	Waste paper	**Food Waste**	**Cow Rumen**
Moisture content (%)	36.22	47.00	41.88
C-Organic (%)	29.25	31.84	24.56
N-Total (%)	0.84	1.86	1.29
C/N	34.94	17.12	19.01

C-Organic describes the organic carbon content of the compost materials. Food waste and waste paper had the highest organic carbon content, whereas cow rumen had the lowest. N-Total indicates the percentage of total nitrogen content in the material. The N-Total value in food waste and cow rumen showed higher nitrogen content than that in wastepaper. Waste paper has a high C/N ratio, which supports microbial activity during composting. In contrast, food waste and cattle rumen have the lowest C/N ratio, a higher nitrogen ratio, and potentially inhibit the activity of microorganisms if there is too much nitrogen.

3.3 Compost Characteristics

Compost volume shrinkage occurs because microorganisms degrade waste into gas during the composting process [11]. Based on the measurement data (**Figure 3**), it can be seen that all six compost variations experienced volume shrinkage of up to 50% for 62 days. Mature compost should experience shrinkage; if the shrinkage is too small, it means that the composting process has not been completed. On day 28 (approximately week 4), the shrinkage of the six compost variations showed a percentage shrinkage of 26.7%-36.7%. Furthermore, on day 62 (week 8), the six compost variations experienced another shrinkage of 50%.

Temperature is one of the factors that plays an important role in the composting process. Based on the measurement data (**Figure 4**), the variations in the six composts resulted in an increase or decrease in temperature for 62 d. The average initial composting temperature ranged from 31.5-32.5oC. On day 2, the compost temperature increased sharply and reached a peak above 50°C within the first day, indicating intense microbial activity in the thermophilic phase aimed at accelerating the decomposition of organic matter. After reaching its peak on the 5th day of composting, the temperature began to decrease gradually, indicating reduced microbial activity because the organic sources that could be decomposed began to deplete. When the composting temperature is in the range of 48-54.5 ℃, then the compost has entered the thermophilic phase.

From day 7 to day 35, the compost temperature tended to stabilize with slight fluctuations until it reached approximately 30°C, indicating the transition from the thermophilic phase to the mesophilic phase, where decomposition occurs more slowly and steadily. After day 35, the temperature of the compost began to approach the ambient temperature, indicating that the decomposition process was approaching its final or mature phase. The temperature in the compost was in accordance with the SNI 19-7030-2004 standard, which is the same as the groundwater temperature. Likewise, according to [12], compost is categorized as mature when the temperature in it has reached the groundwater temperature, approximately ≤30°C.

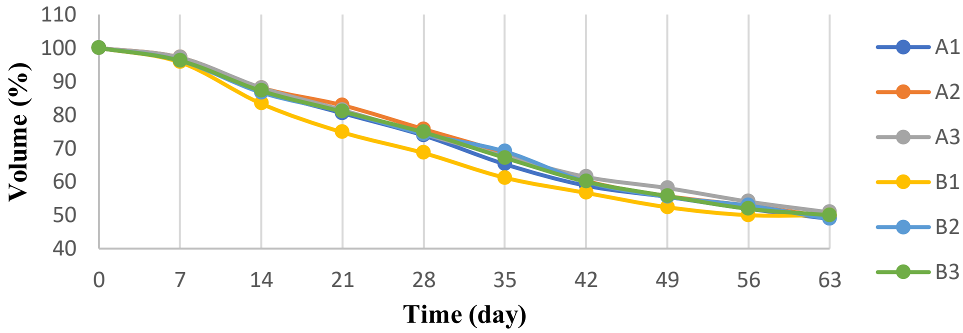

Figure 3. Compost volume for 62 days

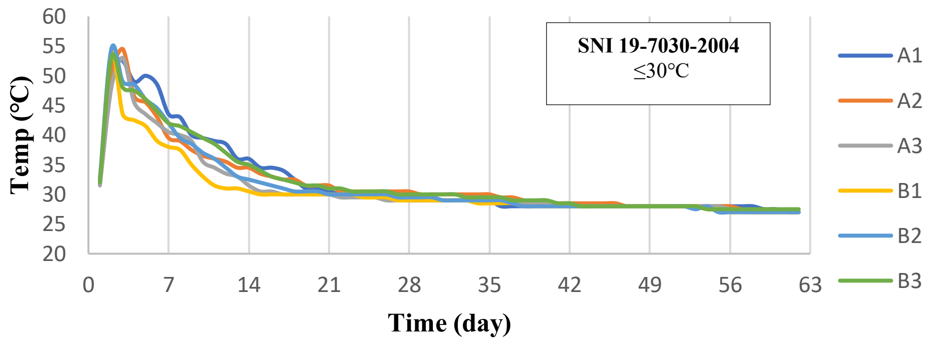

Figure 4. Compost temperature for 62 days

The pH (power of hydrogen) is also an important parameter in the composting process. Based on the data in **Figure 5**, it can be seen that the pH measurements in the six variations started in the range of 6.63–6.80, with a gradual increase in each variation until it approached or reached pH 7. Each variation showed a pattern of pH increase that tended to be the same, although with a slight difference in the time to reach it. At approximately day 35, the pH of all variations approached or reached 7. The pH value tends to be stable because it is influenced by the addition of phosphate buffer pH 7 to the cow rumen fluid used as a biactivator of composting. The pH value of the compost was in accordance with the SNI 19-7030-2004 standard, which is 6.80-7.49.

One of the factors that affects the speed of decomposition during composting is the moisture content. This is because microorganisms require water to decompose organic compounds. Based on the measurement data (**Figure 6**), it can be seen that the six compost variations until week 8 experienced a decrease in moisture content, in the range of 38.33-40.68%. In the 3rd week, variations B1, B2, and B3 decreased the moisture content faster and in accordance with SNI. This is due to the effect of the blower or the addition of air used in the aerated static pile method variation. At week 8, variation B1 had the lowest moisture content, at 38.33%. Meanwhile, A2 variation had the highest moisture content value of 40.68%. In the final results at week 8, all variations decreased. The moisture content of the compost met the standard SNI 19-7030-2004, which is ≤50%.

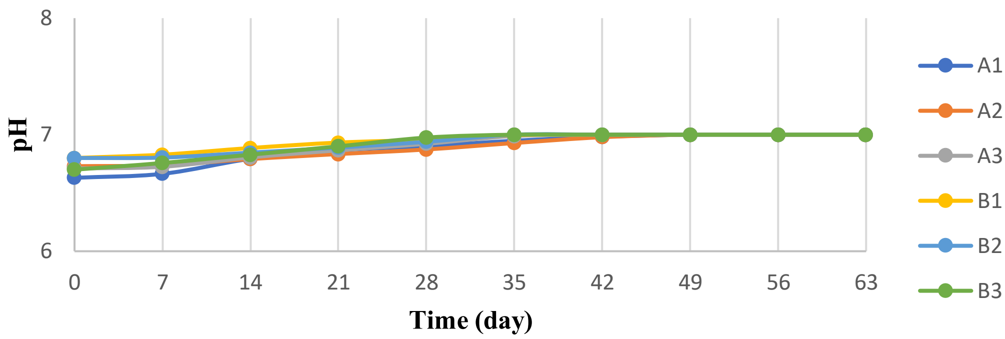

Figure 5. Compost pH for 62 days

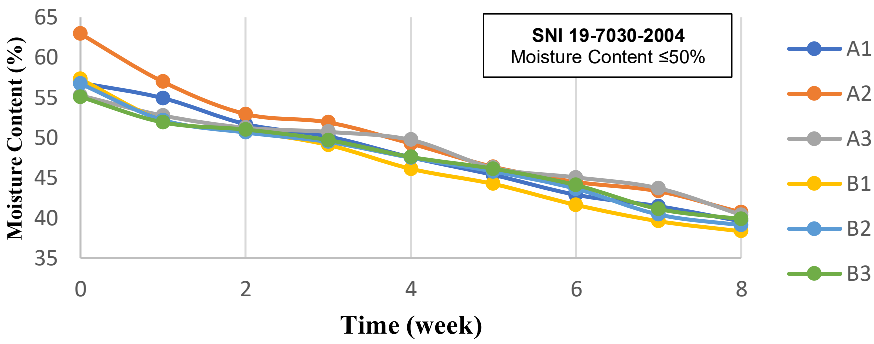

Figure 6. Moisture content in 8 weeks

In the composting process, the level of carbon (C-organic) greatly affects the decomposition rate and quality of the resulting compost. The C-organic content in the compost indicates its ability to improve soil properties. The test results of carbon content (C-Organic) during the composting process (**Figure 7**) on the six compost variations experienced a decrease in carbon content ranging from 20.38-21.32%. From the first week of composting, all variations decreased in accordance with SNI, which was in the range of 23.31-28.00%. At week 8, variation B1 had the lowest carbon content of 20.38%, whereas variation A1 had the highest carbon content of 21.32%. From the first week, there was a significant decrease in the carbon content. This decrease in C-organic content indicates that the activity of microorganisms in the compost degradation process has decreased, and the carbon content as an energy source for microorganisms to decompose organic matter has decreased [13].

The C-organic content of the compost was in accordance with SNI 19-7030-2004, which is 9.80-32.00%.

Microbes require nitrogen for growth and development, including during composting. Microbes consume nitrogen in the compost material, and the element is released again after the compost reaches maturity [14]. The results of the nitrogen testing (N-Total) during the composting process are presented in **Figure 8**. Based on the data in Figure 8, it can be seen that the six compost variations until week 8 experienced an increase in nitrogen levels ranging from 1.11-1.29%. At week 8, variation B1 had the lowest nitrogen content of 1.11%, whereas variations A3 and B3 had the highest nitrogen content of 1.29%. Variations A3 and B3 had the highest nitrogen levels because they used more cow rumen waste, which, according to preliminary tests of compost raw materials, has high nitrogen levels after food waste. Variation B1 had the lowest nitrogen levels because it used more paper waste, which, according to preliminary tests of compost raw materials, has low nitrogen levels. The increase in nitrogen levels of the six variations was in accordance with the SNI.

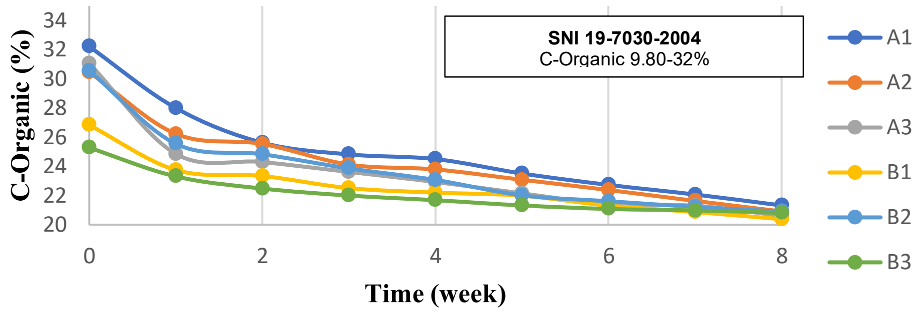

Figure 7. C-Organic of compost for 8 weeks

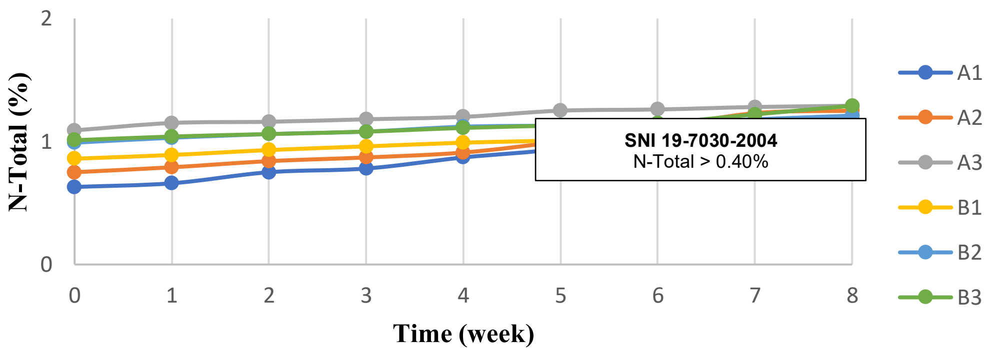

Figure 8. N-Total of compost for 8 weeks

The C/N ratio of organic matter is an important value in the composting process. In the composting process, carbon (C) is used as an energy source for microorganisms, while nitrogen (N) is needed for protein synthesis and cell metabolism or as nutrients for the growth of microorganisms. C/N is also used as an indicator to assess the quality and maturity of compost [15]. Based on the test data (**Figure 9**), it can be seen that in all six compost variations until week 8, the C/N ratio decreased from 15.94-18.44%. In week 4, variations A3 and B3 experienced a faster decrease in the C/N ratio according to SNI, compared to other variations, which amounted to 19.06% and 19.72%, respectively. The final result of compost at week 8, variation A3 had the lowest C/N ratio value of 15.94%, while variation B1 had the highest C/N ratio value of 18.44%. The difference in the C/N ratio was influenced by the composition of the organic materials used in the composting process. Variation A3 uses more cow rumen, which has a low C-Organic content and high N-Total content. Variation B1 uses more paper waste, which has a high C-organic content and a low N-total content.

Indicators for determining the quality of the composting process can be observed from the characteristics and quality of the compost. The overall physical characteristics and quality of the compost at weeks 4 and 8, compared to SNI 19-7030-2004, are shown in **Table 3**. The results showed that within 4 weeks, compost variations A3 and B3 were in accordance with the standard.

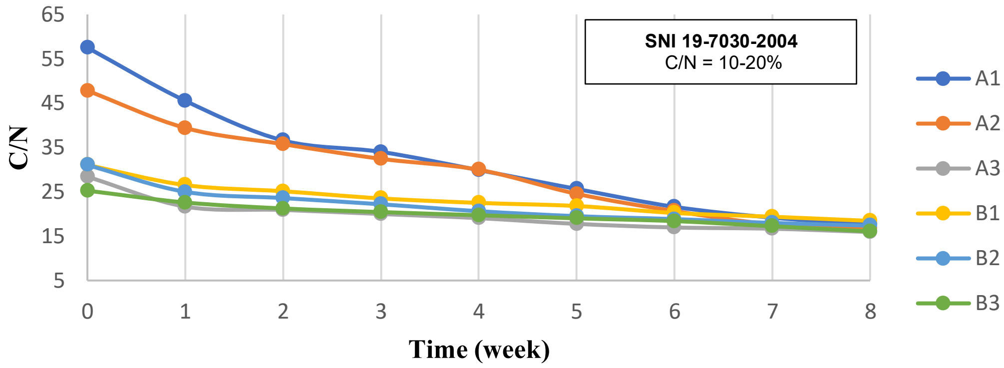

Figure 9. Ratio C/N of compost for 8 weeks

Table 3. Compost quality at 4 and 8 weeks

Composting Week	Parameters	Quality/Variation					
		A1	A2	A3	B1	B2	B3
Week: 4	Color	-	-	+	-	-	+
	Volume Shrinkage	+	+	+	+	+	+
	Temperature (ºC)	+	+	+	+	+	+
	pH	+	+	+	+	+	+
	Moisture Content (%)	+	+	+	+	+	+
	C-Organic (%)	+	+	+	+	+	+
	N-Total (%)	+	+	+	+	+	+
	C/N	-	-	+	-	-	+
Week: 8	Color	+	+	+	+	+	+
	Volume Shrinkage	+	+	+	+	+	+
	Temperature (ºC)	+	+	+	+	+	+
	pH	+	+	+	+	+	+
	Moisture Content (%)	+	+	+	+	+	+
	C-Organic (%)	+	+	+	+	+	+
	N-Total (%)	+	+	+	+	+	+
	C/N	+	+	+	+	+	+

Notes: + = meet the standard SNI 19-7030-2004
- = does not meet the standard SNI 19-7030-2004

3.4 Reduction Potential of waste paper and food waste

According to waste generation measurements conducted by BPKB IPB (2023), food waste and waste paper reached 379.55 kg/day and 679.84 kg/day, respectively. This study showed that the A3 and B3 variations were the best compost variation at 4-8 weeks of composting duration. With a material ratio of 5:1.75:3.25 between food waste, paper, and cow rumen, the use of 255 kg of food waste and 90 kg of paper per day can reduce waste by 67% and 13%, respectively. Cow rumen was obtained from the Faculty of Animal Science IPB Slaughterhouse with an average of 167 kg per day. Composting of A3 and B3 variations for one month was conducted using a block-shaped container with a capacity of 9 m^3. The dimensions of the container were 3 m in length, 2 m in width, and 1.5 m in height. The compost pile required for the application of the selected variation comprised 28 containers. The land areas required were 800 m^2 for variation A3 and 1000 m^2 for variation B3.

4. Conclusion

In the eighth week, the characteristics and quality of compost from the six variations (A1, A2, A3, B1, B2, B3) including color, height, temperature, moisture content, pH, C-Organic, N-Total, and C/N ratio were all in accordance with SNI 19-7030-2004. Variations A3 and B3 met the standard faster (4 weeks). Composting waste paper and food waste using cow rumen bioactivators in variations A3 and B3 for one month reduced waste paper and food waste by 13% and 67%, respectively, at the IPB Dramaga Campus. The land area needed to apply composting A3 variation was 800 m^2, while for the B3 variation, it reached 1000 m^2.

References

[1] Dinarti S, Mahatmaharti AK. 2022. Workshop daur ulang kertas sebagai Upaya menanamkan karakter peduli lingkungan pada siswa Smp Darul Ulum 2 Jombang. *JPM: Jurnal Pengabdian kepada Masyarakat.* 3(2): 224-234. doi: 10.32815/jpm.v3i2.1199.

[2] Sari AP, Diansafitri M, Simbolon VA. 2023. Pengolahan sampah kertas menjadi drawing paper terhadap peningkatan pengetahuan dan sikap siswa sekolah dasar. *Jurnal Sanitasi Lingkungan*. 3(2): 75-82. doi: 10.36086/jsl.v3i2.1989.

[3] Wicaksono AP, Mahfuro R, Risang AL. 2020. Perilaku pengurangan sampah: potensi pengungkapan dan pelaporan keberlanjutan di Perguruan Tinggi. *Jurnal Ilmiah Akuntansi*. 5(1): 151-176.

[4] Yang J, Liang X, Niu T, Meng W, Zhao Z, Zhou GW. 1998. Crystal structure of the catalytic domain of protein-tyrosine phosphatase SHP1. *J Biol Chem.* 273(43): 28199-207. doi: 10.1074/jbc.273.43.28199.

[5] Masithah ED, Choiriyah N, Prayogo. 2011. Pemanfaatan isi rumen sapi yang difermentasikan dengan bakteri bacillus pumilus terhadap kandungan klorofil pada kultur dunaliella salina. *Jurnal Ilmiah Perikanan dan Kelautan*. 3(1): 97-102. doi: 10.20473/jipk.v3i1.11630.

[6] Oktiawan W, Sarminingsih A, Purwono, Afandi M. 2015. Strategi produksi pupuk organik cair komersial dari limbah rumah potong hewan (rph) Semarang. *Jurnal Presipitasi*. 12(2): 89-94. doi: 10.14710/presipitasi.v12i2.86-94.

[7] Laura AC. 2024. Aanalisis komposisi sampah sebagai dasar pemilihan metode pengelolaan sampah pada green building. *Populer: Jurnal Penelitian Mahasiswa*. 3(1): 167-175. doi: 10.58192/populer.v3i1.1849.

[8] Dewi CM, Mirasari DM, Antaresti, Irawati W. 2007. Pembuatan kompos secara aerob dengan builking agent sekam padi. *WIDYA TEKNIK.* 6(1): 21-31. doi: 10.33508/wt.v6i1.1229.

[9] Anungputri PS, Yuliandari P, Suroso E. 2019. Karakterisasi sampah di lingkungan Universitas Lampung. *Journal of Tropical Upland Resources*. 1(1): 171-176. doi: 10.23960/jtur.vol1no1.2019.22.

[10] Nafis D, Yaman MA, Allaily. 2021. Pengaruh lama fermentasi pada pembuatan kompos dari bahan liter ayam, limbah serbuk kayu pinus dan eceng gondok terhadap kualitas fisik. *JURNAL ILMIAH MAHASISWA PERTANIAN*. 6(3): 70-78. doi: 10.17969/jimfp.v6i3.18307.

[11] Addinsyah A, Herumurti W. 2017. Studi timbulan dan reduksi sampah rumah kompos serta perhitungan emisi gas rumah kaca di Surabaya Timur. *JURNAL TEKNIK ITS*. 6(1): 62-67. doi: 10.12962/j23373539.v6i1.22973.

[12] Dewilda Y, Darfyolanda FL. 2017. Pengaruh komposisi bahan baku kompos (sampah organik pasar, ampas tahu, dan rumen sapi) terhadap kualitas dan kuantitas kompos. *Jurnal Teknik Lingkungan UNAND*. 14(1): 52-61. doi: 10.25077/dampak.14.1.52-61.2017.

[13] A'la M, Winarsih. 2021. Pengurangan karbon (c) pada serasah daun angsana (*pterocarpus indicus*) dan daun trembesi (*samanea saman*) melalui metode pengomposan lubang resapan biopori inovatif. *Lentera Bio*. 10(2): 234-244. doi: 10.26740/lenterabio.v10n2.p234-244.

[14] Amnah R, Friska M. 2019. Pengaruh aktivator terhadap kadar unsur c, n, p dan k kompos pelepah daun salak sidimpuan. *Jurnal Pertanian Tropik*. 6(3): 342-347.

[15] Ismayana A, Indrasti NS, Suprihatin, Maddu A, Fredy A. 2012. Faktor rasio c/n awal dan laju aerasi pada proses co-composting bagasse dan blotong. *Jurnal Teknologi Industri Pertanian*. 22(3): 173-179.