JPPIPA 9(4) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Influence of Physico-Chemical and Bioactivators for Composting of Traditional Market Vegetable Waste

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Received: February 20, 2023
Revised: April 21, 2023
Accepted: April 25, 2023
Published: April 30, 2023

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DOI: 10.29303/jppipa.v9i4.3238

Abstract: Reprocessing organic vegetable waste from conventional markets can have beneficial effects, such as producing bioenergy, reducing the need for inorganic fertilizers, and minimizing the volume of contaminants in the environment. Organic material composting can help lower greenhouse gas emissions and generate income. Physical-chemical factors like temperature, pH, particle size, moisture content, aeration, and CN ratio were used to regulate the breakdown process. Trichoderma harzianum, an effective microorganism, and Trichoderma harzianum helped the degradation process function. High-quality compost is produced by converting organic matter in a bioreactor system, where the solid substrate replenishes nutrients. Based on the optimum point of the decomposition procedure, the analytical findings were achieved. After that the material had been homogenized and aerated, this process took place (oxygen). When the temperature is increased, the active and ripening stages take place, which triggers the breakdown process. The ideal temperature for composting, between 30-45 °C, was reached. The temperature steadily drops when the majority of the material has broken down, and the composting process is complete.

Keywords: Bio activators; Biomass; Organic fertilizer; Physico-chemical; Vegetable waste

Introduction

In developing countries, including Indonesia, urban waste is a problem that makes waste disposal that relies heavily on landfill unsustainable. It is the task of the local government in preparing a Waste Management Plan which includes waste reduction and recycling. The overall generation of waste and its physical composition is caused by the increasing rate of population growth. The amount of waste generated in Indonesia in 2016 reached 65,200,000 tons per year with a population of 261,115,456 people (Hidayat et al., 2019). Traditional markets are recognized as a significant source of waste generation. The waste is classified into 60% organic waste, 15% plastic, 10% paper, and 15% metal, glass, cloth, and leather based on composition.

Food waste (animal and vegetable products), vegetables, fruits, fish waste, agricultural and plantation waste, wood trash, leaves, and twigs, as well as animal and human waste, represent the majority of organic waste (Nugraha et al., 2018). The highest accumulation of waste is found in vegetable waste, which is 93.2% (Otoma et al., 2013). Surveys conducted in Vietnam and Thailand reported that organic waste from the market accounted for up to 81.5% and 85% (Ali et al., 2012; Otoma et al., 2013). Traditional markets are also identical as places to shop in slum areas, dirty, unorganized and cause traffic jams (Sholahudin, 2015). Traditional markets consequently turn into a source of environmental degradation. Given the relevance of the role and presence of traditional markets, a traditional market setting that is environmentally friendly, attractive, orderly, and delivers user delight for both traders and consumers is appropriate. With the help of these factors, composting vegetable waste to create organic fertilizer is a development that is achievable.

How to Cite:
Yanqoritha, N. (2023). The Influence of Physico-Chemical and Bioactivators for Composting of Traditional Market Vegetable Waste. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1696–1704. https://doi.org/10.29303/jppipa.v9i4.3238

Recycling efforts for various types of waste to avoid potential negative effects and create a more value product economically. Compost from market waste will reduce dependence on inorganic fertilizers which will have a negative impact on the environment. Market waste composting will decrease reliance on inorganic fertilizers, which will be harmful to the environment. As a source of plant nutrients and organic matter, compost enhances the soil's physical, chemical, and biological qualities (Muhammad Aleem Sarwar et al., 2010). Compost made from organic waste has a higher quality than inorganic fertilizers sold in stores (Chowdhury et al., 2015) and has a benefit that cannot be produced artificially (Harman et al., 2004).

In general, bacteria, actinomycetes, fungi, protozoa, worms, and many types of larvae help the biological breakdown process that takes place during composting. Composting is a biological process that turns microbes into valuable goods under natural or controlled conditions (Daniel Said-Pullicino, 2007) and the biological process is the most economical in waste treatment (Yanqoritha et al., 2022). This microbial community is strongly influenced by the mesophilic phase and the thermophilic phase during the composting process and is also influenced by the physical properties of the waste starting materials (Sudharsan Varma et al., 2015). The composting process is of course also influenced by parameters of physico-chemical properties such as temperature, pH, particle size, moisture content (MC) (Daniel Said-Pullicino, 2007; Juárez-Robles et al., 2017; Onwosi et al., 2017) aeration and CN ratio (Balasubramani Ravindran, 2019; Bhave & Kulkarni, 2019). The purpose of this study was to study the influence of physical and chemical parameters in the decomposition of traditional market vegetable waste into compost using bioactivator of *Trichoderma harzianum* (*Th*) and *Effectiveness Microorganisms* (*Em*$_4$).

In order to allow for the respiration of microorganisms that release carbon dioxide (CO_2) into the environment, enough ventilation must be maintained during the biological composting of aerobic systems. The factors that affect the growth and reproduction of microorganisms, such as parameters of physico-chemical properties of temperature, pH, particle size, MC (Daniel Said-Pullicino, 2007; Juárez-Robles et al., 2017; Onwosi et al., 2017) aeration and CN ratio (Balasubramani Ravindran, 2019; Bhave & Kulkarni, 2019), must be taken into consideration in this aerobic biological process because microorganisms play a significant role in composting. Temperature is the main parameter that must be monitored in the composting process (Chen et al., 2015; Yang Jiang, 2015; Zhao et al., 2016). Temperature is an indicator that shows the activity of decomposing microorganisms during the composting process and also as a function of the process (N. Gamze Turan, 2007). Composting begins at an ambient temperature that can rise without the need for external heating. When during the ripening phase the compost pile reaches ambient temperature. The ambient temperature has various variations depending on the process phase. The initial temperature and the substrate's capacity for biodegradation both have a role in the exothermic process of composting. Due to the faster biodegradation of organic waste by microorganisms during the composting process, temperatures may rise (Raut et al., 2008). Aeration and mixing play an important role in providing ventilation for heat loss to maintain temperature.

The ambient temperature has various variations depending on the process phase. Composting starts at an ambient temperature that can be increased without the need for external heating. When the maturation phase of the compost pile reaches ambient temperature. High temperatures and longer periods of time have a high rate of decomposition and hygiene, so the pile temperature should not drop any faster. Aeration and mixing play an important role in providing ventilation for heat loss to maintain temperature.

The pH value of compost is an important factor for good quality compost (Khater, 2015). A pH meter or potentiometer is used to calculate the pH of organic waste compost. Compost made from organic waste typically has a pH value between 7-8 (Palaniveloo et al., 2020). When organic compounds were degraded, the pH value increased, this was because the composting process that occurs was influenced by dissolved alkali and the formation of ammonia (Hu et al., 2015; Pant et al., 2012). Each stage of the composting process has a different pH value depending on the source material (from 4.5 to 8.5).

The pH of the pile is acidified during the first stage of composting by microorganisms using different organic acids. The medium becomes more alkaline during the thermophilic phase as a result of the conversion of ammonium to ammonia, and the pH eventually stabilizes at a value that is close to neutral. The pH value affects how long microorganisms live, and different types of bacteria have different pH ranges where they can grow and thrive. Most bacterial activity took place between pH 6.0 and 7.5, whereas most fungal activity occurred among pH 5.5 and 8.0. The ideal range is from 5.8 to 7.2 (Karwal & Dutta, 2021).

MC affects the rate of oxygen absorption, free air space, microbial activity, and process temperature (Petric et al., 2012). Microbial activity and composting moisture levels are tightly connected. When microbes use raw materials to move nutrients and energy across cell membranes, the process is known as composting.

The rate of gas diffusion reduces as the water content rises, and the oxygen uptake rate comes up short of the metabolic needs of the bacteria. Due to insufficient activity, the composting process may eventually turn anaerobic (Noor Mohammad, 2012). Composting can result in an increase in water content that can result in a water log, which can cause anaerobic conditions and halt composting process (Makan et al., 2013). When temperature rose, MC also fell, indicating an inverse link between the two (Sudharsan Varma et al., 2015). Low temperatures and excessive humidity were present (N. Gamze Turan, 2007). MC was a useful parameter to measure other important factors such as water availability, which can slow the growth of microbial activity under the low humidity range (Makan et al., 2013). During composting, MC is essential for the distribution of dissolved nutrients required for microbial metabolic activity (Guo et al., 2012). When MC levels rise during composting, a water log may form, creating anaerobic conditions that halt composting activity (Makan et al., 2013). When the moisture content is too low, moisture will not only damage the pathogens in the compost but will also prevent beneficial microbes from behaving as starter cultures (Palaniveloo et al., 2020).

Aeration's impact on composting in an aerobic setting where proper ventilation must be preserved to allow microorganisms to live and release carbon dioxide (CO_2) into the atmosphere. Aeration assists in preventing water filling or compaction of the compost material. However, excessive aeration may cause the temperature to drop and moisture to be lost through evaporation. Additionally, excessive aeration dehydrates microorganisms.

Meanwhile, low humidity can inhibit the decomposition process. In contrast, low aeration rates (usually below 5%), result in excessive humidity which in turn results in excess moisture and an anaerobic environment. A successful operation involves the use of proper mixing ratios (Zhang et al., 2016) optimization of various process parameters such as aeration rate, bulking material, C/N ratio and moisture content (Kazemi et al., 2016) adequate use of bulking agents (Chowdhury et al., 2014).

Microbes use the breakdown of organic molecules in composting to produce energy for their metabolism and collect nutrients to support their population (Marlina et al., 2020). The microorganisms involved in composting require nutrients. The most crucial nutrients are C and N because they both perform crucial roles in cell structure and energy production, respectively (Iqbal et al., 2015). When N was scarce, microbial development slowed down, which led to a gradual breakdown of the available C (A. Hilkiah Igoni, 2008). They also worth noting that extra nitrogen evaporates as ammonia gas if the amount present exceeds the needs of the microbial community. Because C is lost as CO_2 during bio-oxidation, the C/N ratio serves as a gauge of the extent of organic matter decomposition (Lazcano et al., 2008). Due to the advantages of composting, it can be utilized to turn organic matter into valuable products by utilizing microorganisms with degradative properties. It is a commonly used method that converts organic waste into organic fertilizer, recycling the minerals phosphorus, nitrogen, and potassium (Lei Wang, 2015). As a result, compost is now a significant rival in the fertilizer industry (Chowdhury et al., 2014). Thermophilic composting conditions allow for complete compost cleanliness by eradicating harmful organisms found in the trash. Organic material breakdown and humification are results of the composting process (Kulikowska, 2016). Conversely, composting can only be accomplished if the procedure is adequately handled.

Trichoderma spp is a genus of soil-derived, teleomorph-bearing filamentous fungi belonging to the order *Hypocreales* of the division *Ascomycota*. *Trichoderma spp.* genus is genetically very diverse in significance with a number of different abilities with agriculture and industry (Matteo Lorito, 2010; Mona M. El-Shazly & El-Shazly, 2020). *Trichoderma spp*. plays a role in deciphering organic matter in the form of complex compounds containing several components of substances such as Nitrogen (N), Phosphorus (P), Magnesium (Mg), Sulfur (S) and other nutrients needed by plants for their growth. If the composting process uses *Trichoderma spp*. able to hold water so that aeration can be easier (Mega Charisma et al., 2012) and the composting process will be faster (Sepwanti et al., 2016). *Em_4* consists of various mixtures of fermented microorganisms. There are five main groups of microorganisms in *Em_4* that work effectively in fermenting organic matter, namely *photosynthetic bacteria, Lactobacillus sp, Streptomyces sp, yeast (yeast), Actinomycetes* (Contreras-Cornejo et al., 2009; Harman et al., 2004).

Method

Preparation of Tank and Feeding

The tank and feeding in this experiment used 12 reactor tanks with dimensions of 5 liters. Each tank contains a bio activator *Th*, *Em_4*, and as a comparison without a bio activator. The process occurs aerobically, and each bio activator is carried out four times. The decomposition process *uses Th* and *Em_4* bio-activators to accelerate the decomposition of market vegetable waste substrates. A dark green color morphologically characterizes *Th,* its conidiophores are erect, branched, short, thick phialides, and oval conidia (Chaerul & Dewi, 2020). In addition, *Em_4* contains several microbes, especially acidic bacteria and yeast, useful in fermentation (Beck-Friis et al., 2003).

Process of Fermentation

Fungal the mushroom culture was activated and incubated at 25 ^{0}C. Biomass from vegetable waste was cut into small pieces with a length of approximately 3 cm. Energy materials of rice bran and sugar are used to support the activity of decomposing microorganisms. Each treatment used 2.5 kg of biomass plus 0.1 g of bran, 0.52 g of urea, 0.2 g of sugar, and 0.2 L of water and mixed evenly. Then each treatment was given the bio activator *Th* and *Em*$_4$. After the compost material was mixed evenly, in each treatment, it was watered using a solution consisting of 0.2 liters of water, 0.2 grams of sugar, and 0.52 grams of urea. MC was expressed by weight as the mass ratio between wet and dry samples. The criterion for dry samples was a constant sample weight after drying in an oven at temperatures between 100 and 110 ^{0}C. Next, the organic carbon content was determined using an oxidized dichromate; when treated with a few drops of diphenylamine, the remainder of the dichromate was titrated with $FeSO_4$ solution (Otoma et al., 2013). Finally, the total amount of nitrogen was determined by the micro-Kjedhal method (Guebel et al., 1991)

Result and Discussion

Results

This research was conducted with the addition of T. harzianum, Em$_4$, and without activator bioactivators. Each was carried out with four treatments. The composting process was carried out in the active and ripening stages. On the first day, the reactor without bio activator had a temperature of 33.5 ^{0}C and pH of 6.7. On day sixth, the pH increased to 7.08. The reactor containing *Th* activator, at the beginning of the process has a temperature of 32 ^{0}C and pH of 6.28. On the eighth day the process temperature increased by 34 ^{0}C and on the 9th day the pH was 7.35. This was because the start of the active microbe *Th*. At the beginning of the process the reactor filled with *Em*$_4$ activator had a temperature of 30.63 ^{0}C and pH of 6.7. The next day there was a decrease and increase in temperature, on the tenth day the temperature increased by 32.25 ^{0}C and pH 7.5 on the fifth day. In this condition, the *Em*$_4$ microbes started to become active. The temperature profile of the composting process with and without *Em*$_4$ and *Th* showed different trends as shown in Figure 1.

The composting process in each reactor was carried out until the compost ripening process. Microorganisms in the process used oxygen to decompose organic matter into CO_2, water vapor and heat. After most of the material decomposes, the temperature gradually decreased. The composting process in a reactor without an activator was slower in decomposing waste into compost. On day 42, the temperature in the reactor filled with *Th* was 28.5 ^{0}C and pH 6.99. The reactor filled with *Em*$_4$ and without pH activator was 7.00 and 6.98, respectively. On day 42, the temperature of the reactor filled with *Th* has reached room temperature and the pH was neutral.

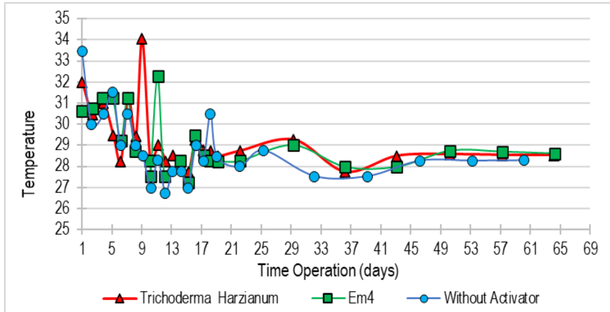

Figure 1. Profile of process temperature

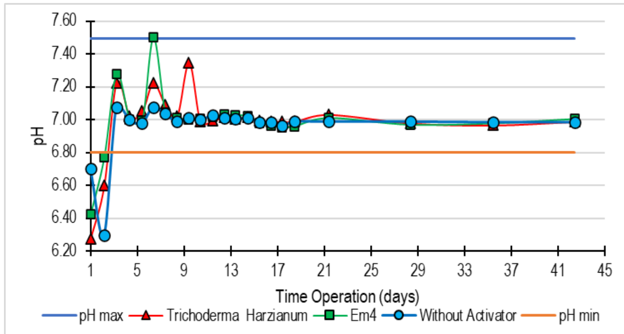

Figure 2. Profile of process pH

Due to the fact that various microorganisms can grow at various pH levels, the pH of the compost's initial raw materials has a minimal to no effect on the composting process (Figure 2). Between 6.5 and 8.0 is the optimal range for microbial activity. Temperature and oxygen concentration both affect how organic acids are formed and decomposed by microbes. A faster rise in pH resulted from faster acid decomposition and lower maximum organic acid concentrations in the compost that were caused by higher oxygen concentrations (Beck-Friis et al., 2003).

The oxygen in the pore space was rapidly depleted during an active composting process, requiring a steady stream of fresh air necessary to maintain an aerobic environment. The quantity of evaporation and the addition of water from precipitation during the composting process cause the moisture conditions in the pile to fluctuate constantly. The water content of the compost was maintained at a humidity level between 40 and 60%. The water content decreased on the first day of composting due to an increase in temperature which indicated the activity of microorganisms. Because microorganisms need an adequate water content to digest organic material, MC had an impact on the pace of compost decomposition and temperature variables.

Large quantities of nutrients are needed by microorganisms. The macronutrients carbon (C), nitrogen (N), phosphorus (P), and potassium are among examples (K) (Graves, 2000). Analysis for nitrogen, carbon, phosphorus, and the C/N ratio followed a 42-day period of investigation. The key nutrient content indication and the factor with the biggest impact on the composting process is the ratio of carbon to nitrogen. Since carbon and nitrogen were the primary indicators of nutritional content, they had to be present in the proper proportions in order for other nutrients to be likely to be present in reasonable amounts as well.

Microbial growth required a source of energy, which was carbon. A portion of the carbon in aerobic composting was released as CO_2, and the remaining carbon was mixed with nitrogen to promote microbial development. As a result, the compost pile's carbon content was dropping.

The sample and nitrogen content (%) showed that the reactor filled with bio activator (*Th*, *Em*$_4$) and without activator was 0.4825%, 0.6975% and 0.595%, all in accordance with SNI standards that was > 0.4% (Figure 3). Samples and levels of Phosphorus (%), indicated that each reactor was filled with bio activator: *Th*, *Em*$_4$ and without bio activator, all > 0.1%, namely for *Th* 0.316%, *Em*$_4$ 0.5535% and without bio activator 0.4445% (Figure 4). Sample and carbon content (%), indicated that the reactor was filled bio activator: *Th*, *Em*$_4$ were 5.325%, 6.42% and SNI standard was > 9.8% (Figure 5).

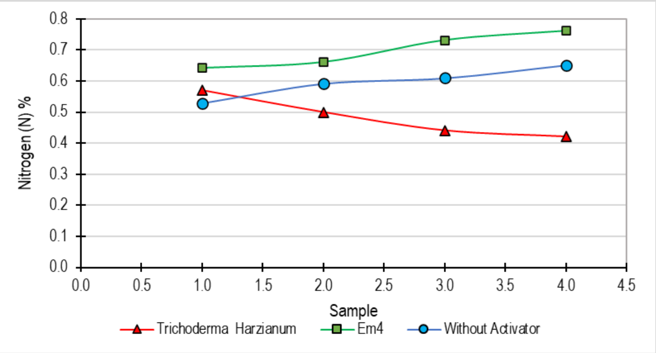

Figure 3. Profile of nitrogen content

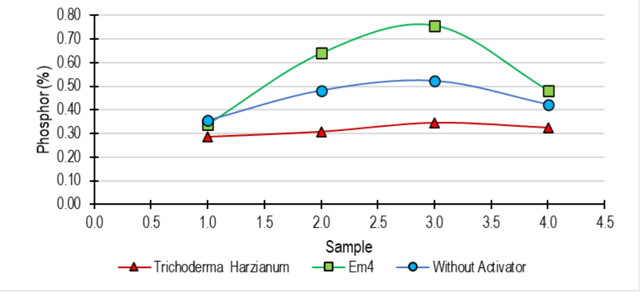

Figure 4. Profile of phosphor content

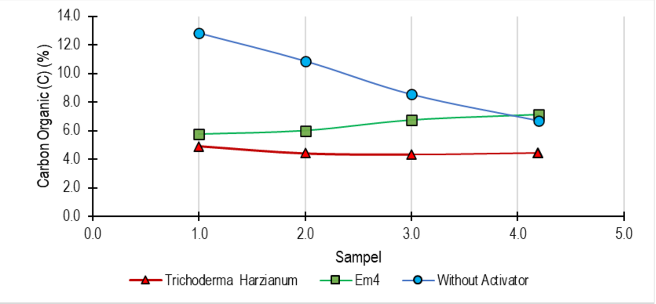

Figure 5. Profile of carbon content

Sample of C/N ratio showed that the reactor was filled bio activator: *Th*, *Em*$_4$ were 8.67 and 9.03 while the SNI standard was > 9.8% (Figure 6). Although the CN ratio is important, it is not the only parameter because the properties of the material to be decomposed inevitably have a profound effect on the rate of decomposition. Materials rich in tannins and phenols may take longer to decompose than materials rich in cellulose, even though both have identical CN ratio. That is, while bacteria attempt to maintain a healthy C/nutrient ratio, a C-rich feed causes microbes to emit more C as CO_2 into the atmosphere (Manzoni et al., 2010). *Em*$_4$, *Th*, which corresponded to the optimization point of the graphs C, N, C/N and P ratio according to the SNI compost table was compost that used *Th* activator, namely 4.94, 0.57, 8.67, and 0.287. *Em*$_4$ were 5.78, 0.64, 9.03 and 0.341.

Discussion

The composting process took place after the raw materials were mixed in each reactor. Composting occurred when the process of consuming oxygen generated heat energy and a dynamic microorganism system that was so active that it changed the conditions of its own environment. Active mesophilic microorganisms < 45 ^{0}C, while thermophilic microorganisms have an optimum temperature above that.

Increases in pH during composting have been observed to occur more quickly under high oxygen concentration and low temperature circumstances (Sundberg & Jönsson, 2008). The initial temperature and the substrate's capacity for biodegradation both have a role in the exothermic process of composting (Kulikowska, 2016). Composting occurred when a community of microorganisms breaks down organic matter for mostly aerobic growth and reproduction. By adjusting the compost pile's carbon-nitrogen (C: N) ratio, oxygen supply, moisture content, temperature, and pH, microorganism activity was increased. Decomposition of a well-managed composting process to increase the rate of natural composting.

Decomposition generated enough heat to break down and decompose organic matter to grow and reproduce weed seeds, pathogens, and fly larvae (Graves, 2000). The rapid increase in temperature indicated that there were mostly easily degradable substances in the raw materials (Che Jusoh et al., 2013). Heat produced by the population of microbes' respiration and the breakdown of sugars, starches, and proteins during composting is what led to the rise in temperature. Since higher temperatures were associated with greater microbial activity, they are a solid indicator that there was activity in the compost heap. A large percentage of the vegetable waste was biodegradable, according to the temperature pattern, which showed a quick transition from the early mesophilic phase to the treatment. Temperature was the main factor as an exothermic reaction that affected the degradation of organic compounds and evaporation of water (Chen et al., 2015; Raut et al., 2008; Zhang et al., 2016). The main control parameter for the activity of microbes during the breakdown of organic matter was temperature. The composting process will operate at its optimum if the temperature necessary for the growth of microorganisms was reached (Priyambada & Wardana, 2018).

Conclusion

The increase in temperature affected the increase in the release of CO_2. On the 8th day the temperature reached 34 ^{0}C and the 42nd day the reactor temperature reached 29.25 ^{0}C and for Em_4 on the 10th day it reached 32.25 ^{0}C and on the 42nd day it reached 28.75 ^{0}C. it means that Th has the most effective microbes compared to Em_4 activator. Depending on the chemical properties of the waste and the stoichiometric requirements of the decomposer, the dynamics of carbon, nitrogen, and phosphorus in decomposing activity against decomposition provide a recognizable pattern of immobilization and nutrient release. Our findings demonstrated that lowering the initial nitrogen and phosphorus concentrations in the litter increased the critical C:N and C:P ratios, under which nutrients were released. We propose that this pattern could be explained by a decrease in the efficiency of carbon used by decomposers and, in the tropics, by an increase in decomposers based on the theoretical notion of a critical carbon: nutrient ratio. higher leaching rate and C:P ratio. These elements, especially in the tropics, permitted the release of nutrients from plant wastes with low nutritional concentrations. Therefore, the litter N:P ratio by itself may not be a good indicator for anticipating the initial nutrients released during decomposition in tropical systems. These insights will be tested using specific measurements of the microbial carbon:nutrient ratios in litter from various climatic areas. The benefit of this research is to determine the optimization of psycho-chemical parameters and bioactivators. So that it can be more precise and effective at the time of application and decomposition of vegetable waste into organic compost.

Acknowledgements

Thanks to prima indonesia university for its financial support, the authors express their gratitude.

References

Ali, G., Nitivattananon, V., Abbas, S., & Sabir, M. (2012). Green waste to biogas: Renewable energy possibilities for Thailand's green markets. *Renewable and Sustainable Energy Reviews*, *16*(7), 5423–5429. https://doi.org/10.1016/j.rser.2012.05.021

Beck-Friis, B., Smårs, S., Jönsson, H., Eklind, Y., & Kirchmann, H. (2003). Composting of Source-Separated Household Organics At Different Oxygen Levels: Gaining an Understanding of the Emission Dynamics. *Compost Science & Utilization*, *11*(1),41–50. https://doi.org/10.1080/1065657X.2003.10702108

Bhave, P. P., & Kulkarni, B. N. (2019). Effect of active and passive aeration on composting of household biodegradable wastes: a decentralized approach. *International Journal of Recycling of Organic Waste in Agriculture*,*8*,335–344. https://doi.org/10.1007/s40093-019-00306-7

Chaerul, M., & Dewi, T. P. (2020). Analisis Timbulan Sampah Pasar Tradisional (Studi Kasus: Pasar Ujungberung, Kota Bandung). *Al-Ard: Jurnal Teknik Lingkungan*, *5*(2), 98–106. https://doi.org/10.29080/alard.v5i2.861

Che Jusoh, M. L., Abd Manaf, L., & Abdul Latiff, P. (2013). Composting of rice straw with effective microorganisms (EM) and its influence on compost quality. *Iranian Journal of Environmental Health Science and Engineering*, *10*(17). https://doi.org/10.1186/1735-2746-10-17

Chen, Z., Zhang, S., Wen, Q., & Zheng, J. (2015). Effect of aeration rate on composting of penicillin mycelial dreg. *Journal of Environmental Sciences*, *37*, 172–178. https://doi.org/10.1016/j.jes.2015.03.020

Chowdhury, A. K. M. M. B., Konstantinou, F., Damati, A., Akratos, C. S., Vlastos, D., Tekerlekopoulou, A. G., & Vayenas, D. V. (2015). Is physicochemical evaluation enough to characterize olive mill waste compost as soil amendment? The case of genotoxicity and cytotoxicity evaluation. *Journal of*

CleanerProduction,*93*,94–102. https://doi.org/10.1016/j.jclepro.2015.01.029

Chowdhury, A. K. M. M. B., Michailides, M. K., Akratos, C. S., Tekerlekopoulou, A. G., Pavlou, S., & Vayenas, D. V. (2014). Composting of three phase olive mill solid waste using different bulking agents. *International Biodeterioration and Biodegradation*,*91*,66–73. https://doi.org/10.1016/j.ibiod.2014.03.012

Contreras-Cornejo, H. A., Macías-Rodríguez, L., Cortés-Penagos, C., & López-Bucio, J. (2009). Trichoderma virens, a plant beneficial fungus, enhances biomass production and promotes lateral root growth through an auxin-dependent mechanism in arabidopsis. *Plant Physiology*, *149*(3),1579–1592. https://doi.org/10.1104/pp.108.130369

Daniel Said-Pullicino. (2007). Changes in the chemical characteristics of water-extractable organic matter during composting and their influence on compost stability and. *Bioresource Technology*, *98*(9), 1822–1831. https://doi.org/10.1016/j.biortech.2006.06.018

Graves. (2000). Part 637 Environmental Engineering National Engineering Handbook. In Mary R. Mattinson (Ed.), *National Engineering Handbook* (pp.1–71). Retrieved from https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=28910.wba

Guebel, D. V., Nudel, B. C., & Giulietti, A. M. (1991). A simple and rapid micro-Kjeldahl method for total nitrogen analysis. *Biotechnology Techniques*, *5*(6), 427–430. https://doi.org/10.1007/BF00155487

Guo, R., Li, G., Jiang, T., Schuchardt, F., Chen, T., Zhao, Y., & Shen, Y. (2012). Effect of aeration rate, C/N ratio and moisture content on the stability and maturity of compost. *Bioresource Technology*, *112*, 171–178. https://doi.org/10.1016/j.biortech.2012.02.099

Harman, G. E., Howell, C. R., Viterbo, A., Chet, I., & Lorito, M. (2004). Trichoderma species - Opportunistic, avirulent plant symbionts. In *Nature Reviews Microbiology* (Vol. 2, Issue 1, pp. 43–56). https://doi.org/10.1038/nrmicro797

Hidayat, Y. A., Kiranamahsa, S., & Zamal, M. A. (2019). A study of plastic waste management effectiveness in Indonesia industries. *AIMS Energy*,*7*(3),350–370. https://doi.org/10.3934/ENERGY.2019.3.350

Hu, W., Zheng, G., Fang, D., Cui, C., Liang, J., & Zhou, L. (2015). Bioleached sludge composting drastically reducing ammonia volatilization as well as decreasing bulking agent dosage and improving compost quality: A case study. *Waste Management*,*44*,55–62. https://doi.org/10.1016/j.wasman.2015.07.023

Iqbal, M. K., Nadeem, A., Sherazi, F., & Khan, R. A. (2015). Optimization of process parameters for kitchen waste composting by response surface methodology. *International Journal of Environmental Science and Technology*, *12*(5), 1759–1768. https://doi.org/10.1007/s13762-014-0543-x

Juárez-Robles, B., de la Rosa-Gómez, I., Mañon-Salas, M. del C., Hernández-Berriel, M. del C., Vaca-Paulín, R., & Lugo-de la Fuente, J. (2017). Quality and time of biosolid compost when varying ratios and weight of substrates. *Revista Chapingo Serie Ciencias Forestales y Del Ambiente*, *23*(3), 401–410. https://doi.org/10.5154/r.rchscfa.2016.12.065

Karwal, M., & Dutta, D. (2021). Composting: Phases and Factors Responsible for Efficient and Improved Composting. *Agriculture & Food*, *3*(01), 85–90. https://doi.org/10.13140/RG.2.2.13546.95689

Kazemi, K., Zhang, B., Lye, L. M., Cai, Q., & Cao, T. (2016). Design of experiment (DOE) based screening of factors affecting municipal solid waste (MSW) composting. *Waste Management*, *58*, 107–117. https://doi.org/10.1016/j.wasman.2016.08.029

Khater, E. S. G. (2015). Some Physical and Chemical Properties of Compost. *International Journal of WasteResources*,*05*(01). https://doi.org/10.4172/2252-5211.1000172

Kulikowska, D. (2016). Kinetics of organic matter removal and humification progress during sewage sludge composting. *Waste Management*, *49*, 196–203. https://doi.org/10.1016/j.wasman.2016.01.005

Lazcano, C., Gómez-Brandón, M., & Domínguez, J. (2008). Comparison of the effectiveness of composting and vermicomposting for the biological stabilization of cattle manure. *Chemosphere*,*72*(7),1013–1019. https://doi.org/10.1016/j.chemosphere.2008.04.016

Lei Wang. (2015). Methyl Jasmonate Primed Defense Responses Against Penicillium expansum in Sweet Cherry Fruit. *Plant Molecular Biology*, *33*, 1464–1471.

Makan, A., Assobhei, O., & Mountadar, M. (2013). Effect of initial moisture content on the in-vessel composting under air pressure of organic fraction of municipal solid waste in Morocco. *Iranian Journal of Environmental Health Science and Engineering*, *10*(3). https://doi.org/10.1186/1735-2746-10-3

Manzoni, S., Trofymow, J. A., Jackson, R. B., & Porporato, A. (2010). Stoichiometric controls on carbon, nitrogen, and phosphorus dynamics in decomposing litter. In *Ecological Monographs* (Vol. 80, Issue 1). https://doi.org/10.1890/09-0179.1

Marlina, E. T., Badruzzaman, D. Z., Harlia, E., Hidayati, Y. A., & Susilawati, I. (2020). Microbial Population Dynamics and Fiber Reduction In The Initial Decomposition Of Beef Cattle Waste Composting. *Ziraa'ah*, *45*(1), 94–102. Retrieved from https://ojs.uniska-bjm.ac.id/index.php/ziraah/article/viewFile/2657/2009

Mega Charisma, A., Sri Rahayu, Y., Jurusan Biologi, I., Matematika dan Ilmu Pengetahuan Alam, F., & Acvrida Mega Charisma. (2012). Pengaruh Kombinasi Kompos Trichoderma dan Mikoriza Vesikular Arbuskular (MVA) terhadap Pertumbuhan Tanaman Kedelai (Glycine max (L.) Merill) pada Media Tanam Tanah Kapur. *LenteraBio*, *1*(3), 111–116. Retrieved from https://garuda.kemdikbud.go.id/documents/detail/1538011

Mona M. El-Shazly, & El-Shazly, M. M. (2020). Role Of Trichoderma Spp. In Improving Compost Properties. *Plant Archives*, *20*(2), 8353–8362. Retrieved from http://plantarchives.org/20-2/8353-8362%20(7095).pdf

Muhammad Aleem Sarwar, Bot, P. J., & Anjum, S. A. (2010). Appraisal of Pressmud and Inorganic and anorganic Fertilizer Sugarcane and Sugarcane Quality effect of Nitrogen on Growth and Yield of Sugarcane. *Pak. J. Bot*, *42*(2), 1361–1367. Retrieved from https://rb.gy/3tw5v

N. Gamze Turan. (2007). The effects of natural zeolite on salinity level of poultry liter compost. *Bioresource Technology*, *99*(7), 2097–2101. https://doi.org/10.1016/j.biortech.2007.11.061

Noor Mohammad. (2012). Effective composting of oil palm industrial waste by filamentous fungi: A review. *Resources, Conservation and Recycling*, *58*, 69–78. https://doi.org/10.1016/j.resconrec.2011.10.009

Nugraha, A., Sutjahjo, S. H., & Amin, A. A. (2018). Analisis Persepsi dan Partisipasi Masyarakat terhadap Pengelolaan Sampah Rumah Tangga di Jakarta Selatan. *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal of Natural Resources and Environmental Management)*, *8*(1), 7–14. https://doi.org/10.29244/jpsl.8.1.7-14

Onwosi, C. O., Igbokwe, V. C., Odimba, J. N., Eke, I. E., Nwankwoala, M. O., Iroh, I. N., & Ezeogu, L. I. (2017). Composting technology in waste stabilization: On the methods, challenges and future prospects. *Journal of Environmental Management*,*190*,140–157. https://doi.org/10.1016/j.jenvman.2016.12.051

Otoma, S., Hoang, H., Hong, H., Miyazaki, I., & Diaz, R. (2013). A survey on municipal solid waste and residents' awareness in Da Nang city, Vietnam. *Journal of Material Cycles and Waste Management*, *15*(2), 187–194. https://doi.org/10.1007/s10163-012-0109-2

Palaniveloo, K., Amran, M. A., Norhashim, N. A., Mohamad-Fauzi, N., Peng-Hui, F., Hui-Wen, L., Kai-Lin, Y., Jiale, L., Chian-Yee, M. G., Jing-Yi, L., Gunasekaran, B., & Razak, S. A. (2020). Food waste composting and microbial community structure profiling. In *Processes* (Vol. 8, Issue 6, pp. 1–30).MDPIAG. https://doi.org/10.3390/pr8060723

Pant, A. P., Radovich, T. J. K., Hue, N. V., & Paull, R. E. (2012). Biochemical properties of compost tea associated with compost quality and effects on pak choi growth. *Scientia Horticulturae*, *148*, 138–146. https://doi.org/10.1016/j.scienta.2012.09.019

Petric, I., Helić, A., & Avdić, E. A. (2012). Evolution of process parameters and determination of kinetics for co-composting of organic fraction of municipal solid waste with poultry manure. *Bioresource Technology*,*117*,107–116. https://doi.org/10.1016/j.biortech.2012.04.046

Priyambada, I. B., & Wardana, I. W. (2018). Fast decomposition of food waste to produce mature and stable compost. *Sustinere: Journal of Environment and Sustainability*, *2*(3), 156–167. https://doi.org/10.22515/sustinere.jes.v2i3.47

Raut, M., Prince Wiliam, S., Bhattacharyya, J., Chakrabarti, T., & Devotta, S. (2008). Microbial dynamics and enzyme activities during rapid composting of municipal solid waste – A compost maturity analysis perspective. *Bioresource Technology*,*99*(14),6512–6519. https://doi.org/10.1016/j.biortech.2007.11.030

Ravindran, B., Nguyen, D. D., Chaudhary, D. K., Chang, S. W., Kim, J., Lee, S. R., ... & Lee, J. (2019). Influence of biochar on physico-chemical and microbial community during swine manure composting process. *Journal of environmental management*, 232, 592-599. https://doi.org/10.1016/j.jenvman.2018.11.119

Sepwanti, C., Rahmawati, M., & Kesumawati, E. (2016). Pengaruh Varietas dan Dosis Kompos yanf diperkaya Trichoderma harzianum Terhadap pertumbuhan dan hasil Tanaman Cabai Merah (Capsicum annuum L.). In *Jurnal Kawista* (Vol. 1, Issue 1). Retrieved from https://jurnal.usk.ac.id/agrotek/article/view/3243

Sholahudin, U. (2015). Pasar Modern dan Hancurnya Hak Sosial-Ekonomi Pedagang Tradisional (Studi Kasus Menjamurnya Pasar Modern dan Dampaknya Terhadap Hak Berusaha Pedagang Tradisional Di Kota Surabaya. *Jurnal Politika* , *1*(1).

Sudharsan Varma, V., & Kalamdhad, A. S. (2015). Evolution of chemical and biological characterization during thermophilic composting of vegetable waste using rotary drum composter. *International Journal of Environmental Science and Technology*,*12*(6),2015–2024. https://doi.org/10.1007/s13762-014-0582-3

Sundberg, C., & Jönsson, H. (2008). Higher pH and faster decomposition in biowaste composting by increased aeration. *Waste Management*, *28*(3), 518–526. https://doi.org/10.1016/j.wasman.2007.01.011

Yang Jiang. (2015). Rapid production of organic fertilizer by dynamic high-temperature z. *Bioresource Technology*, *197*, 7–14. https://doi.org/10.1016/j.biortech.2015.08.053

Yanqoritha, N., Kuswandi, & Sulhatun, S. (2022). Evaluation of Kinetic Parameters of Nitrification Process in Biofilter System to Efluent Liquid Waste of Tofu Industry. *Jurnal Penelitian PendidikanIPA*,*8*(6),2744–2751. https://doi.org/10.29303/jppipa.v8i6.2453

Zhang, H., Li, G., Gu, J., Wang, G., Li, Y., & Zhang, D. (2016). Influence of aeration on volatile sulfur compounds (VSCs) and NH3 emissions during aerobic composting of kitchen waste. *Waste Management*,*58*,369–375. https://doi.org/10.1016/j.wasman.2016.08.022

Zhao, X. lan, Li, B. qiong, Ni, J. pai, Xie, D. ti, NiI, J., & Xie, D. ti. (2016). Effect of four crop straws on transformation of organic matter during sewage sludge composting. *Journal of Integrative Agriculture*,*15*(1),232–240. https://doi.org/10.1016/S2095-3119(14)60954-0