Performance On Nitrogen Rich Component for Composting of Food Waste

Irnis Azura Zakarya[1,2*], *Somendiran* Muniandy[1], *Tengku Nuraiti* Tengku Izhar[1,2], *Nor Anis Nadhirah* Md Nasir[1], *Muna'amirah* Mohamad[3] and *Georgeta* Tudor[4]

[1]Faculty of Civil Engineering & Technology, Universiti Malaysia Perlis, 02600 Arau, Malaysia
[2]Sustainable Environment Research Group (SERG), Centre of Excellence Geopolymer and Green Technologies (CEGeoGTech), Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia.
[3]E-Idaman Sdn. Bhd. Wisma Idaman, Alor Setar, Kedah, Malaysia.
[4]National Instiute for Research and Development in Environmental Protection, Splaiul Independenţei 294, Bucharest, Romania, 060031

Abstract. Nitrogen-rich components are crucial to achieving successful composting. The problem lies in the lack of comprehensive understanding and evaluation of the performance of different nitrogen-rich components used in composting food waste. The objective of this study was to evaluate the performance of nitrogen-rich components (NRC) (cow dung, tea leaves, and coffee ground) for composting food waste in terms of compost quality (temperature, moisture content, nutrients content, and plant growth height). The materials used in composting are 1kg of NRC, 1kg of black soil, 1kg of rice husk, 2kg of food waste, and 1 L of Takakura EM in every compost bin. A total of 4 composts were examined, such as compost A (cow dung), B (coffee ground), C (tea leaves), and D (blank). During the composting process, all parameters of the compost were examined, and data collected. Firstly, total nitrogen (N) content results for compost A, B, C, and D are 1.2%, 1.6%, 3%, and 0.7%, respectively, whereas total phosphorus (P) content in compost A, B, C, and D is 3.7 mg/L, 3.8 mg/L, 5 mg/L, and 3.01 mg/L. Lastly, the potassium (K) content in compost A, B, C, and D is 4.56 mg/L, 4.1 mg/L, 5.13 mg/L, and 4.6 mg/L, respectively. Based on the data analysis, Compost C is the most effective compost compared to other NRC compost.

1 Introduction

Composting is the biological breakdown of wastes made of organic materials from plants or animals under controlled conditions until they are stable enough to be stored and used [1]. A key factor in successful composting is the presence of nitrogen-rich components, as nitrogen plays a crucial role in the decomposition process and the quality of the final compost [2]. The objective of this research is to investigate and evaluate the performance of different nitrogen-rich components for composting food waste. By comprehensively analysing the effectiveness

* Corresponding author: irnis@unimap.edu.my

and efficiency of these components, valuable insights can be gained to optimize the composting process and improve the quality of the resulting compost.

The selection of suitable nitrogen-rich components is crucial in achieving successful composting. Different materials such as cow dung, coffee ground and tea leaves have been recognized for their high nitrogen content and potential contributions to the composting process [2]. However, a comprehensive understanding of their performance is currently lacking. This research aims to address this knowledge gap by evaluating and comparing the performance of these nitrogen-rich components. Therefore, analysing the nutrient composition, specifically nitrogen content, of the resulting compost will provide insights into the effectiveness of the nitrogen-rich components in enriching the compost with essential plant nutrients. Initially, the chemical characteristics of each NRC will be examined before using it in the compost. Based on their chemical characteristics, three NRC, such as tea leaves, cow dung, and coffee ground, were chosen to be used in this composting process. During the composting, each compost containing different NRC was tested for its physical and chemical characteristics to evaluate the most effective compost that contained nitrogen as its main element. This research will contribute to the knowledge gap in NRC composting by detailing the NRC chemical characteristics and how they contribute to the performance of composting.

The outcome of this research will contribute to the advancement of sustainable food waste management practices by providing information on the performance of nitrogen rich component (cow dung, coffee ground and tea leaves) by analysing the physical and chemical properties of these compost where involved parameters nutrient content (N, P, K) and the plant growth measurement.

2 Material and Method

2.1 Nitrogen Rich Component

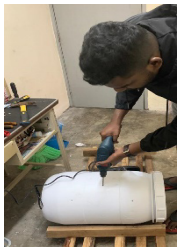
The NRC used in this study are cow dung, coffee ground and tea leaves with an amount of 1kg each. Cow dung was and tea leaves were collected from laboratory while spent coffee ground were collected from Starbucks, Kangar Jaya, Perlis. The spent coffee ground was dried under sunlight for 1 day before composting due to higher moisture content. This was done to avoid any disturbance to the compost due to its moisture content. All these NRC were weighted to be 1kg before composting.

2.2 Composting Method

Aerobic composting was used in this study where the usage of air circulation is crucial for decomposition of food waste. Figure 1 shows the composting bin that was poked with several holes to enable air circulation. The compost bin was made of HDPE material. It also won't affect the chemical composition of the compost. Others component needed for composting such as effective microorganisms (EM), NRC, food waste (FW), black soil (BS) and rice husk (RH) are prepared with following ratio for each compost A, B, C and D:

I. Compost A: (1kg BS + 1kg FW + 1kg RH +1L EM + 1kg Cow Dung)
II. Compost B: (1kg BS + 1kg FW + 1kg RH +1L EM + 1kg Coffee Ground)
III. Compost C: (1kg BS + 1kg FW + 1kg RH +1L EM + 1kg Tea leaves)
IV. Compost D: (1kg BS + 1kg FW + 1kg RH +1L EM)

(a)



(b)

Fig. 1. Compost Bin Setup (a) Composting bin used and (b) Holes drilled on compost bin

All the compost was prepared and placed in the compost bin according to the content above. The compost material will be mixed well and let it to rest for the process to begin. The compost bin will be placed in an area without direct sunlight exposure and room temperature. The compost microbial activity will be examined by the presence of white structure on the compost after 1 or 2 days of composting. This white structure formation indicates the presence of microbial activity in the compost. Addition of food waste will be made weekly 3 times continuously for 1 month. Mixing and turning will be done daily for aeration that provide oxygen for microorganism for microbial activity, moisture distribution and temperature regulation. Compost sample A, B, C and D will be taken every 3 days once until the end of composting period to analyse the chemical and physical properties of the compost.

2.3 Plant Growth

Plant growth and number of leaves analysis was done to determine the most effective and efficient compost fertilizer to be used in plantation. Thus, we had chosen *Ipomoea aquatica* (water spinach) plant seeds to plant growth to examine the plant growth height and number of leaves growth. The plant's seeds were planted in the seedling tray. Each of the seedling tray's pot were placed about ¾ quarter of compost and ¼ quarters of black soil. The plant was watered daily. The growth was monitored and recorded every 4 days.

3 Results and Discussion

Evaluation and comparison of the performance on nitrogen rich component for composting of food waste was done by analysing the physical and chemical characteristics (nutrient content and plant growth height) of the compost fertilizer.

3.1 Total Phosphorus (P) during composting

The Figure 2 shows the effect of total nitrogen during composting process of four different sample namely A, B, C and D. In general, it can be seen that all the compost had an increment trend that shows the nitrogen content had increased gradually over the compost period of 33 days. The initial N value for compost C higher compared to other nitrogen material.

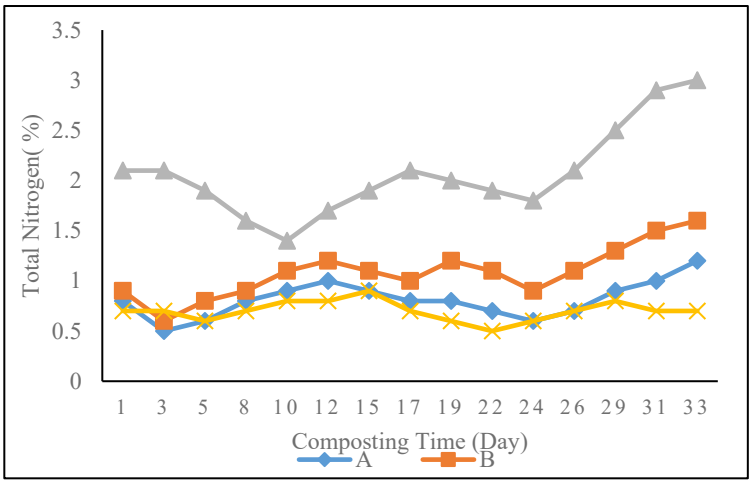


Fig 2. Total nitrogen during composting process

The initial value of all the compost is stated to be more than 0.6% which is considered above the suggested range for compost based on previous research [3]. The slight depletion in the graph for all the compost may cause by the microorganism present in the compost use nitrogen during the process to build up cells which caused the depletion in the amount of nitrogen in the early stages of composting process which was experienced in research conducted previously [4]. After a slight depletion, the graph of all compost continuously increased. During the process of building up cells, some of these organisms die and are recycled as nitrogen. Thus, this contributes to the increase of nitrogen content due to stored source of nitrogen [5, 6]. Besides, the increase in nitrogen content is caused by an increase in inorganic nitrogen because of the concentration effect as a consequence of strong degradation of organic carbon compound [5]. Compost C had achieved the highest N percentage among all the compost. Compost C final nitrogen percentage is 3% which is in the suggested range which is more than 0.6% [3].

3.2 Total Phosphorus (P) during composting

Figure 3 shows phosphorus data for composting. Generally, the graph shows a continuous increment phase as it approaches the end day of composting. The highest initial value obtained by compost B with 1.86 mg/L while lowest initial value obtained by compost C with 1.06 mg/L. Whereas, the highest final P concentration obtained by compost C with 4.2 mg/L and lowest P concentration obtained by compost D with 3.01 mg/L.

The increase in the phosphorus during composting was possibly caused by concentration effect arising from the higher rate of carbon loss that occurs when organic matter is decomposed [7]. Although, all the compost experiences an increment phase along the composting period but the final composting period considered to be lower due to leaching out the P in organic substances where in research stated that decrease in amount of P may results in leaching out P as soluble organic solute [8]. Another possible reason for lower P concentration caused by the formation of insoluble phosphorus compounds during composting [9].

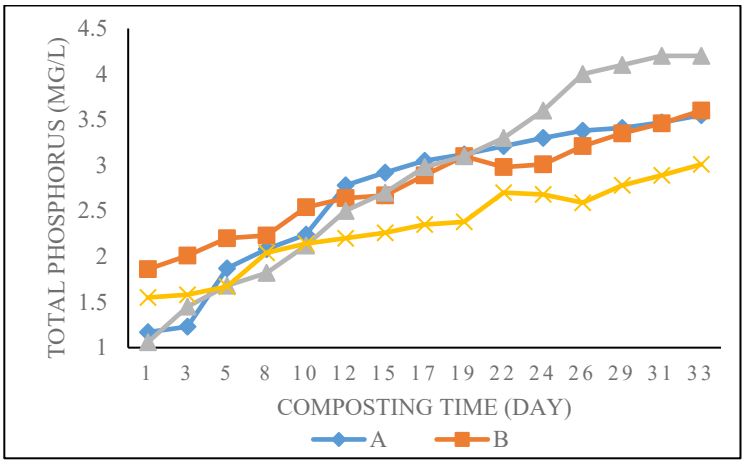


Fig 3: Total Phosphorus (P) during composting

Compost C had achieved a highest P concentration among all compost sample. The high P concentration value affect by the high loss of carbon happen during the decomposition of organic substances [10].

3.3 Total Potassium (K) during composting process

Figure 4 shows effect of total potassium during the composting process for four different composts namely A, B, C and D. Generally, the graphs show an increase trend where it can be seen that total potassium of all compost increases gradually. The initial K value for all compost ranges from 2.3 mg/L to 3.3 mg/L. There is a slight fluctuation in the graph increasing pattern as it moving towards the end of composting period. The final K value for all the compost ranges from 4.5 mg/L to 5.1 mg/L. This value shows that there is a significant increase in the value at the end of composting period with highest K value at the end of composting obtained by compost C.

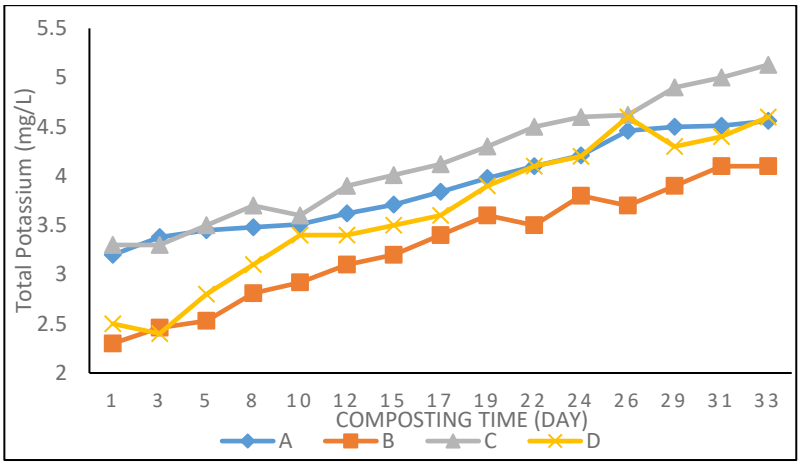


Fig 4: Total Potassium (K) during composting

The increase was due to the higher microbial activity in all compost which consequently caused a higher rate of mineralization [3]. It is important to note that parameter such as

temperature, moisture content and pH affects the potassium concentration in the compost [11]. The fluctuation in the graph along with the gradual increase caused by the activity of microorganisms in compost can be unstable, which can cause fluctuations in the total potassium content reading. The total potassium during the composting process had shown a positive result for all the compost. However, compost C achieved the highest potassium (K) concentration compared to others compost sample.

3.4 Plant Growth Height Measurement

Figure 5 shows the pattern of *Ipomoea Aquatica* or also known as water spinach plant height over planting time about 32 days. This plant height study was done on four different compost sample name A, B, C and D to study their effectiveness in contributing to the plant growth. At initial, all the compost had 0 cm growth because we had planted using seeds of the water spinach plant. On the 4th day of planting, there were significant growth in all compost sample where the highest growth was noticed to be on compost C with the height value of 1.1 cm while the lowest growth was noticed to be on compost B with 0.5 cm. On the mid of planting day which was on day 16, it was noticed that all the plants in all compost had a good increasing significant growth. Compost C again managed to get highest growth in height after 16 days of planting with the height of 4 cm.

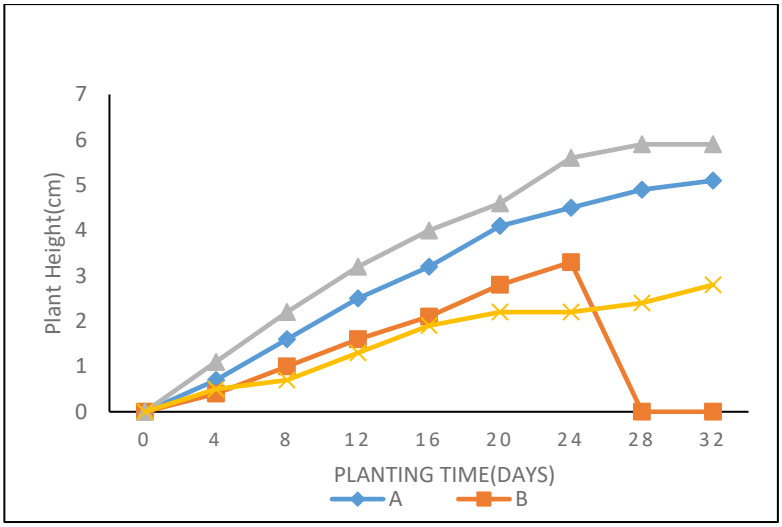


Fig 5: Measurement of plant growth measurement

There was a sudden fall for compost B sample where it had a steep fall after day 22 of planting. During this time, it was noticed that Compost B plant had wilted suddenly. This might have caused by the potassium(K) concentration was noticed to be lower compared to other compost during the time period of wilting where there was a significant concentration different when compared to other compost. Compost C had the highest initial and final height growth in overall. Compost C had the best results in the graph analysis for the measurement of effectiveness of compost fertilizer using in term of plant growth height.

4 Conclusion

In conclusion, Compost C had achieved to most optimal physical and chemical parameter for compost when compared to other compost. Compost C achieved highest and most optimal

range when compared to other compost with 3% for nitrogen, 5 mg/L for phosphorus and 5.13 mg/L for potassium. Moreover, Compost C had attained with the highest plant growth in term of height with 5.9 cm after 32 days of planting. To conclude this research, Compost C or tea leaf compost is the most effective and efficient compost among all the other nitrogen rich compost.

Acknowledgement

The authors would like to extend their gratitude to the E-Idaman Sdn. Bhd under grant (2019/12/001) for their assistance and kindness during the sampling collection and testing. Special thanks to the Faculty of Civil Engineering & Technology at UniMAP for providing the laboratory facilities for this study.

References

1. M. Díaz, M. E. Eugenio, L. Jiménez, E. Madejón, and F. Cabrera, *Modelling vinasse/cotton waste ratio incubation for optimum composting*, Chemical Engineering Journal **93**, 3 (2003)
2. G. Bélanger *et al.*, *Nitrogen availability from dairy cow dung and urine applied to forage grasses in eastern Canada*, Canadian Journal of Plant Science, **95**, 1 (2015)
3. H. Hamid *et al.*, *Organic Fertilizer from Food Waste by Composting in UTHM Campus Pagoh*, Journal of Design for Sustainable and Environment, **1**, 1 (2019)
4. S. N. B. Khalib, I. A. Zakarya, and T. N. Tengku Izhar, *Composting of Garden Waste using Indigenous Microorganisms (IMO) as Organic Additive*, International Journal of Integrated Engineering **10**, 9 (2018)
5. P. L. and G. Bishop, *Nitrogen transformation during sludge composting*, Biocycle, **24** (1993)
6. G. F. Huang, J. W. C. Wong, Q. T. Wu, and B. B. Nagar, *Effect of C/N on composting of pig manure with sawdust*, *Waste Management,* **24**, 8 (2004)
7. P. S. Murthy and M. Madhava Naidu, *Sustainable management of coffee industry by-products and value addition—A review*, Resour Conserv. Recycl. **66** (2012)
8. Mwazi, *Evaluation of the effects of salinity on spinach (Beta vulgaris var. cicla) grown in a hydroponic system along the coast of Namibia.,* Agricola, **20** (2010)
9. M. Jakubus, *Estimation of phosphorus bioavailability from composted organic wastes*, Chemical Speciation & Bioavailability, **28**, 1–4 (2016)
10. S. N. Jamaludin, A. Abdul Kadir, and N. W. Azhari, *Study on NPK Performance in Food Waste Composting by Using Agricultural Fermentation*, MATEC Web of Conferences **103** (2017)
11. M. Lalremruati and A. S. Devi, *Duration of Composting and Changes in Temperature, pH and C/N Ratio during Composting: A Review*, Agricultural Reviews (2021)