Multidisciplinary Applied Research and Innovation Vol. 3 No. 2 (2022) 25-30

MARI

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/mari
e-ISSN :2773-4773

Anaerobic Decomposition of Domestic Waste from Eggshells, Tea and Coffee Grounds for Organic Fertilizer

Muaz Azmin[1], Siti Noraiza Ab Razak[1, 2,*] Fazlinuddin Azman[1], Irfan Zulkornain[1]

[1]Department of Science and Mathematics, Center for Diploma Studies, Universiti Tun Hussein Onn Malaysia, KM1 Jalan Panchor, 84600, Muar, Johor, MALAYSIA

[2] Microelectronics and Nanotechnology - Shamsudin Research Centre (MiNT-SRC), Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, MALAYSIA

DOI: https://doi.org/10.30880/mari. 022.03.02.004
Received 31 March 2022; Accepted 31 May 2022; Available online 28 July 2022

Abstract: The purpose of this project is to produce an organic fertilizer from domestic waste such as eggshells, coffee grounds and tea powder at an optimum ratio. The method used to compost the raw materials into a fertilizer was anaerobic decomposition method. The significance of the project is to reduce groundwater contamination as well as accumulation of salt in soil that will cause a toxic chemicals to the environment through an active used of synthetic fertilizer by farmers. Moreover, such domestic waste are usually stranded rotting which accumulates to greenhouse gases such as methane. The use of an organic fertilizer is an alternative solution to this problem since it can reduce domestic waste pollution and overcome side effects of inorganic fertilizer. Fourier-Transform Infrared Spectroscopy (FTIR) is used to analyse the functional groups of fertilizer and universal pH paper is used to check the pH of soil that grows an okra after fertilization. C-H compound is the main functional group present in fertilizer through FTIR analysis. The best ratio of eggshells, coffee and tea powder is 1:1:1 respectively since it provides neutral pH 7 to soil for okra planting and will cause the okra tree to grow healthier.

Keywords: Anaerobic decomposition, coffee ground, domestic waste, eggshells, organic fertilizer

1. Introduction

Fertilizer plays an important role in enhancing plant growth and crops because it contains many nutrients to plant. The main reason why plants must be fertilized is because sometimes the soil does not provide essential nutrients for plants. Fertilizer can be produced organic or synthetic and also exists in a few forms like pellets, powder or liquid. Both synthetic and organic fertilizer include at least three important macronutrients for plants which are Nitrogen (N), Phosphorus (P) and Kalium (K). It has

*Corresponding author: noraiza@uthm.edu.my

been proven that fertilizer usage can increase plant crops. Fertilizer application contributes to more than 40 % of grain production, which is important for China. The grain production uses 9 % of the world's arable land, produces 24 % of the world's grain and feeds 18 % of the world's population [1].

Most nitrogen fertilizers are obtained from synthetic ammonia (NH_3). This chemical compound of NH_3 is used either as a gas or in a water solution, or it is converted into salts such as ammonium sulphate, ammonium nitrate, and ammonium phosphate, but packinghouse wastes, treated garbage, sewage, and manure are also common sources of it [2]. Applications of nitrogen fertilizers are responsible for emissions of greenhouse gases. Some microorganisms can transform nitrogen compounds in synthetic fertilizer into nitrous oxide (N_2O) and NH_3. Besides supplying nitrogen, ammonia can also increase soil acidity and pest problems The long term effect of excess application of N often results in the eutrophication of surface water, a problem popularly known to be highly noxious to water-bodies [3]. Eutrophication will promote growth of algae and unwanted plants into the water body, this can cause high usage of oxygen in the water body and can make aquatic organisms unable to live.

Development of organic fertilizer requires a bit more effort because the process will undergo naturally. Compared to synthetic fertilizer, it can be produced easily and in a short time. Organic fertilizers are made from any organic things from animals and plants. To produce organic fertilizer, there are three methods to use; anaerobic, aerobic and vermicomposting. Anaerobic composting is decomposition by microorganisms that demand oxygen to survive. Aerobic composting goes the same way but the microorganisms require oxygen to survive. Vermicomposting is decomposition of organic matter by worms. Earthworms can degrade practically all kinds of organic matter by feeding on them. They can eat their body weight per day. For example, earthworms that weigh 0.1 kilogram can eat 0.1 kilogram of residue per day [4].

In this project, anaerobic decomposition method was proposed with the additional use of bokashi that acted as probiotic agent for enhancing degradation process. Bokashi is an anaerobic fermentation product from solid agricultural by-products and bokashi is the growth medium for the micro-organisms, and provides a suitable micro-environment for EM in the soil [5]. Materials used are from domestic waste such as eggshells, tea and coffee grounds that are collected for free. In addition, dry leaves are also added to absorb excessive moisture and as carbon sources for microbes. These ingredients will be put inside the container and will be moistened a little bit of water and will let it for two weeks. The fertilizer produced is completely decomposed with less odour, no warm vapour and better texture.

2. Materials and Methods

The materials used and method in producing organic fertilizer through anaerobic process will be discussed in details in this section. In addition, the observation method of okra growth will also be explained.

2.1 Materials

The materials used in this experiment are eggshells, tea and coffee grounds. All the materials were collected from local restaurants which are Restaurant Nasi Ayam Madu Pak Anjang, Pahang and Warung Zeezan, Melaka. Dried leaves used are grasses and sugarcane, which are abundantly available at author's village side road. Besides, an effective microbes (EM) probiotic reagent called bokashi was bought at Bioterra shop from online shopping application, Shopee. The okra seeds are allowed to grow for the first three weeks and later will be fertilized by the end product of organic fertilizer. Okra seeds was purchased from Yap Piang Seng shop.

2.2 Methods

The first step is the preparation of the raw materials. The eggshells are dried, soaked with vinegar for a few hours before being crushed into smaller particles. Then, the sample is placed into a closed container containing a few drops of bokashi probiotic. Wasted tea and coffee grounds are being used to ensure that the end product is less acidic and softer. Next, the wasted coffee grounds will be mixed with bokashi so that it can be easily decomposed. Following that, approximately 7 ml of water is added into the sample to provide moisture for living organisms to survive. A crushed dried leaf is then put at the top of the sample inside the container to absorb excessive moisture and to act as carbon source for microbes. The mixture is then compressed before closing the container. These steps are repeated with a wasted tea powder sample, prepared in a separate container. All samples are left for two weeks for the decomposition process to take place. Later, the functional group of all composted material, together with the mixture of the composted material containing a combination of eggshells, coffee ground and tea powder will be analysed using FTIR.

Once the sample is decomposed, the fertilizer will be prepared in three sets of different ratios of mixed domestic waste of eggshells: coffee: tea that is 1:1:1, 1:2:3 and 3:2:1 ratio. The prepared organic fertilizer is then used to fertilize an okra tree, growing in different pots. In order to identify the effect of different ratio on okra growth, two more control samples are included for observation, which is planting an okra without being fertilized and also using a synthetic fertilizer, respectively. The pH litmus is used to check the pH level of soil after being fertilized for three weeks. The parameters of okra growth are in terms of the number of leaves, plant height and number of fruit produced.

3. Results and Discussion

The analysis and observation result will be discussed as following sub-topic:

3.1 FTIR Analysis

FTIR was used to examine the makeup of chemicals contained in each type of composted materials which is eggshells, coffee grounds, tea powder and the mixture of all composted materials by identifying the functional group. The main functional group in all composted materials is C-H Alkene. Compost eggshells contain the highest intensity of C-H alkene at wavenumber range 3090 to 3005 cm^{-1} and at 750 to 665 cm^{-1}. Meanwhile, tea fertilizer contains the lowest intensity of C-C Alkene which at wavenumber 1650 to 1605 cm^{-1}. The most important factor that influences the intensity of an infrared absorption band is the change in dipole moment that occurs during a vibration [6]. **Table 1** shows the tabulated data of all functional groups present in composted eggshells, coffee grounds, tea powder, and also the mixture of all composted materials.

Table 1: The functional group contained in the composted materials.

Functional Group	Wave Number (cm^{-1})	Coffee ground	Tea powder	Eggshells	Mixture
C-H Alkene	3090 to 3005	Low	Lowest	Highest	Low
C-H Alkyl	2905 to 2900	Low	Highest	Lowest	Low
C=C Alkene	1650 to 1605	Lowest	Low	Highest	Low
C-F	1050 to 1000	Lowest	Low	Highest	Low
C-Br	6500 to 550	Low	Lowest	Highest	Low

From the **Table 1**, all functional groups present in mixture of composted materials that is being used as fertilizer shows a low intensity, despite of highest intensity of certain functional group present in individual composted material. However, the preferred amount of functional groups are within a

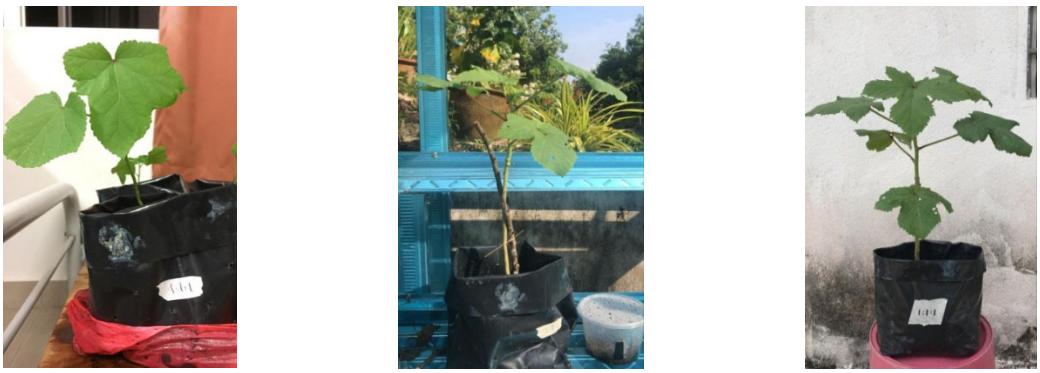
desired level for the fertilizer to grow the plant. The simplest alkene, ethylene, is itself a plant hormone, and controls the ripening and colour development of fruit. The use of alkenes that common people may not know is as artificial ripening. The double bond in alkenes help to make the ripening process of fruits faster. Artificial ripening is laboratory processed additive to help farmers not to lose the unripe fruits during harvesting by letting the rest of the fruits ripe using artificial ripening [7].

3.2 Growth Parameter of Okra Plant

Table 2: Parameters of okra plant after 3 weeks fertilised

Sample / Week	Height of plant (cm)			Number of leaves		
	W1	W2	W3	W1	W2	W3
1:1:1	30.5	45.5	56.5	5	5	7
1:2:3	20.5	31.0	41.7	5	6	5
3:2:1	25.5	27.0	44.0	5	6	7
No fertilizer	23.5	26.5	35.0	5	6	6
Chemical fertilizer	23.5	27.0	44.0	5	7	7

Table 2 shows the result of growth parameters of okra tree after fertilization for three weeks. For the first week, it seems all of the okra plants have the same number of leaves. For height, most of them have average height of 20.5 to 25.5 cm except for sample 1:1:1 which is 30.5 cm. From the result, the sample 1:1:1 indicates the best growth since three is significant growth from 30.5 cm in the first week to 56.5 cm in the third week, so it grows as much as 26 cm. Besides, okra without fertilizer had the least growth of height, from 23.5 cm to 44 cm in the final week. This is because okra trees do not have enough nutrition contained in soil and stunted the growth of trees. For the number of leaves, all okra plants have the same number of leaves which is 5. Most fertilizers contain the main nutrients that all plants needed that are N, P and K element, but one may need to supplement one of these elements depending on soil and the type of plant [8]. For the final week, samples 1:1:1, 3:2:1 and chemical fertilizer are the highest number of leaves, which is 7. The least number of leaves is sample 1:2:3. Based on the result, it is concluded that sample 1:1:1 shows the best growth parameters from all of the samples. The growth of an okra using 1:1:1 fertilizer ratios from the first to third week is shown in **Figure 1**.



Week 1 **Week 2** **Week 3**

Figure 1: The observation growth of an okra plant fertilized by 1:1:1 ratios for three weeks

3.3 The pH Level of Soil

Soil pH is generally not a problem as okra grows well in soils that are slightly acidic to slightly alkaline (pH 6.5 to 7.5) [9]. The pH of soil is measured after three weeks. For okra plants that grow without being fertilized, and are fertilized using organic fertilizer of ratio 1:2:3 and 3:2:1, and also fertilized by synthetic fertilizer, the pH level in week three is 6. This pH level of soil is maintained just like before the okra is being planted. Even though the pH is a bit acidic, it is still within the soil pH tolerance for an okra. However, for fertilizer with ratio 1:1:1, the soil pH is increased to pH 7. This shows that the sample with ratio 1:1:1 caused the soil pH to change from slightly acidic to neutral level. Most plants thrive in slightly acidic soil because that pH affords them good access to all nutrients. At a high pH level, the plant nutrient molybdenum becomes available in toxic amounts [10]. Acidic soil is also important to plant because bacteria that release organic matter operate efficiently in soils that are slightly acidic. Nevertheless, in order to prevent an environmental problem and soil pollution, fertilizer with ratio 1:1:1 fertilizer is chosen as the optimum ratio for okra plantation.

4. Conclusion

In conclusion, anaerobic composting takes place naturally and it works easily with domestic waste. It is known that the application of organic fertilizers or materials brings about long-term improvements in the soil's physical and chemical characteristics rather than immediate and specific nutrient availability effects as in the case of mineral fertilizer. . With the advanced method of effective-microbes bokashi has been shown that speed-up the process of decomposition and reduce the odour of compost. It also makes the texture of fertilizer less soggy and more subtle. The suitable ratio of fertilizer is sample 1:1:1 for okra plants since it indicates the best result from all analysis done. The application of anaerobic composting will help to reduce emission of greenhouse gases and soil contamination and is suitable for all trees.

Acknowledgement

This research is supported by the Ministry of Education Malaysia under The Fundamental Research Grant Scheme for Research Acculturation of Early Career Researchers (FRGS Racer) Vot RACER/1/2019/STG02/UTHM//1 and partially sponsored by Universiti Tun Hussein Onn Malaysia, UTHM.

References

[1] R. He, C. Shao, R. Shi, Z. Zhang, and R. Zhao, "Development trend and driving factors of agricultural chemical fertilizer efficiency in China," *Sustain.*, vol. 12, no. 11, 2020, doi: 10.3390/su12114607.

[2] M. Bashir, S. Ali, A.Izni, and R. Harun, "Impact Of Excessive Nitrogen Fertilizers On The Environment And Associated Mitigation Strategies," *Asian J. Microbiol. Biotechnol. Environ. Sci.*, vol. 15, pp. 213–221, Jul. 2013.

[3] E. o. E. Britannica, "Britannica," 28 November 2019. [Online]. Available: https://www.britannica.com/topic/fertilizer. [Accessed 23 June 2019].

[3] M. S. Ayilara, O. S. Olanrewaju, O. O. Babalola, and O. Odeyemi, "Waste management through composting: Challenges and potentials," *Sustain.*, vol. 12, no. 11, pp. 1–23, 2020, doi: 10.3390/su12114456.

[4] J. Dawid, "Organic Fertilizers Requirement of Coffee (Coffea Arabica L) Review," vol. 4, no. 7, pp. 11–18, 2018.

[5] K. Shin, G. Van Diepen, W. Blok, and A. H. C. Van Bruggen, "Variability of Effective Micro-

organisms (EM) in bokashi and soil and effects on soil-borne plant pathogens," 2017, doi: 10.1016/j.cropro.2017.05.025.

[6] E. Z., "Socratis Q&A," Socratis Q&A, 18 January 2015. [Online]. Available: https://socratic.org/questions/what-are-the-factors-that-influence-the-intensity-of-an-ir-absorption-band.

[7] Dwipurwa, "AzChemistry.com," AZ Chemistry, 20 June 2018. [Online]. Available: https://azchemistry.com/uses-of-alkanes-alkenes-and-alkynes-in-industry.

[8] M. Malone, "What Causes Plant Stunting," SFGATE, 23 November 2020. [Online]. Available: https://homeguides.sfgate.com/causes-plant-stunting-38935.html.

[9] R. Jauron, "Iowa State University," ISU Extension and Outreach, 13 April 2005. [Online]. Available: https://hortnews.extension.iastate.edu/2005/4-13-2005/okra.html.

[10] L. Reich, "The Four Things You Need to Know About Soil pH," fine gardening, [Online]. Available: https://www.finegardening.com/article/the-four-things-you-need-to-know-about-soil-ph.