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Research Article

Macro Nutrient Availability of a Liquid Fertilizer Formulated From Vegetable Waste and Laundry Disposal Water

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Abstract: Increasing human activities produced various types of organic wastes such as agricultural residues and domestic waste. Inappropriate management of these wastes create environmental problem such as land and water pollutions. Utilization of these wastes could solve their indiscriminate disposal problems in this study. Wet anaerobic digestion process was used to produce liquid fertilizer by mixing untreated laundry disposal water with different ratio of vegetable waste's weight as follows T1 (vegetables waste:laundry disposal water 1:20 w:v), T2 (vegetables waste:laundry disposal water 1:10 w:v), and T3 (vegetables waste:laundry disposal water 1:5 w:v), respectively. Afterwards, these formulated liquid fertilizers was left incubated and harvested at 0, 3, 6, 9, 12, and 15 days of fermentation and analyzed for pH, NH_4-N, NO_3-N, and total of P, K, Ca, Mg and Na content using standard procedures. Generally, T3 formulated fertilizer contain higher total K with acidic pH, 4 to 5. Rapid degradation of organic acids might cause reduction of the pH of formulated liquid fertilizers whereas the surface size of the vegetable wastes increased nutrients dissolution. Generally, higher amount of vegetables wastes are needed to increase the nutrients availability in formulated liquid fertilizers.
Keywords: liquid fertilizer, vegetables waste, wastewater, laundry disposal water, macro nutrient availability.

INTRODUCTION

The increasing human population has increased resources consumption including energy, water, food and raw materials which contribute to mass production of waste. In 2015, approximately 38,000 tonnes of waste was generated daily or 12.8 million tonnes per year in Malaysia. It is predicted by 2020, waste production will increase to 15.6 million tonnes (Alias *et al.*, 2018). With this scenario, Malaysia is facing with waste management issues as open dumping, landfilling and incineration are the major disposal methods (Zainu and Songip, 2017).

Open dumping, landfilling and incineration were proven to contribute to environmental degradation, mainly through the production of highly polluting leachate and methane gas emission. Methane gas constitutes one of the six greenhouse gases responsible for the global warming while leachate contaminated groundwater (Tweib *et al.*, 2011). Meanwhile discharge of wastewater that rich in nitrogen, phosphorous and other nutrients into water stream can lead to oxygen depletion, increased turbidity, eutrophication as well as microbial and water contamination in the aquatic systems (Hussain *at el., 2002;* Morel and Diener, *2006;* Sabeen *at el., 2018*).

Recently, more studies have been carried out to search for alternative solution to handle wastes. A process of producing organic liquid fertilizer known as wet anaerobic digestion has been developed, which utilizes the natural process of fermenting organic materials and water base sources to produce liquid of nutrients. Even though, the major purpose of anaerobic digestion is to produce biogas, it also produces solid and liquid by-products, which value as a fertilizer or soil amendment (Cioabla *et al.*, 2012).

Agricultural waste such as vegetable waste is a biodegradable material generated in large quantities. It is considered a good organic input material, because of high yield of methane with varying organic loading and

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it is relatively easy to decompose (Abu Bakar *et al.*, 2014; Singh *et al.*, 2012). Siegristet al. (1976) estimated that 65% of all wastewater generated in a household is greywater that contain nutrients such as N, P, K, and other micro elements and also organic matter (Khai *et al.*, 2008). Therefore, anaerobic digestion is particularly suitable for the treatment of wastes with high moisture contents such as vegetable and water wastes (Asquer *et al.*, 2013). Due to their abundance and renewability, utilization of these wastes may develop sustainable technique for agricultural proposes. Thus, this study was carried out to evaluate the macro nutrient availability in liquid fertilizer formulated from vegetables wastes mixture with laundry disposal water.

MATERIAL AND METHODS

Site Study

The production of formulated liquid fertilizer was done at the Soil Science Laboratory, Department of Crop Science, Universiti Putra Malaysia Bintulu Sarawak Campus Malaysia. It was conducted under controlled condition with the temperature around 25 to 30 °C.

Selected Wastes Collection and Preparation

Laundry disposal water discharge from washing machine was collected from dormitory of Universiti Putra Malaysia Bintulu Sarawak Campus, Malaysia. It was abundance and easy to collect in large quantity. The collected waste water was stored in polyethylene containers at room temperature before further use in formulating liquid fertilizer. The vegetable wastes used are mainly the outer dry parts and/or whole spring onion and cabbage wastes which are poor in quality and unsuitable for sale. The wastes collected from the local markets and were oven-dried at 60 °C (without being wash) remove the excess water content. After that, dried wastes were grounded, mixed thoroughly, and stored in air tight polyethylene container for further use.

Liquid Fertilizer Formulation

An oven-dried vegetable wastes was placed into 250 mL polyethylene bottle before mixed with untreated laundry disposal water with different ratio of vegetable waste's weight as follows T1 (vegetables waste:laundry disposal water 1:20 w:v), T2 (vegetables waste:laundry disposal water 1:10 w:v), and T3 (vegetables waste:laundry disposal water 1:5 w:v), respectively. Then, the bottles containing the mixtures were sealed to prevent flies and odor emissions and left it to incubate. The liquid extracts were harvested at the end of fermentation periods which were 0, 3, 6, 9, 12, and 15 days. Liquid sample was filter using Whatman filter paper No. 2 into a plastic vial before further tested for liquid fertilizer characterization.

Liquid Fertilizer Characterization

The initial wastes material and the formulated liquid fertilizers samples were characterized for pH (Peech, 1965), total N (Bremner, 1965), and selected total cations content extracted using dry ashing method (Cheftetz *et al.*, 1996) before determined by using an Atomic Absorption Spectrometer (PerkinElmer AAnaylst 800). Total P Content of laundry disposal water and liquid fertilizer samples was determined using UV-Vis spectrophotometer (PerkinElmer Lambda 25) at 882 nm after Molybdenum Blue method (Murphy and Riley, 1962). Total ammonium (NH_4-N) and nitrate (NO_3-N) was determined using Keeney and Nelson method (1982). All samples were analyzed in triplicate.

RESULTS AND DISCUSSION

Selected nutrients composition of the waste materials used in formulating fertilizer

Table 1 shows that laundry disposal water was slightly alkaline (8.2) with high Na concentration (2390.3 mg L^{-1}), and has very low concentrations of Ca (22.1 mg L^{-1}), K (13.9 mg L^{-1}) and Mg (3.67 mg L^{-1}). The NH_4-N, NO_3-N and P were high in the order of NH_4-N > NO_3-N > P with the value of 770.6, 469.3, and 334.4 mg L^{-1}, respectively. The pH of the vegetable waste was acidic (5.6) with high Ca concentration (10235 mg L^{-1}) and low concentration of Na (226.4 mg L^{-1}). The NH_4-N, NO_3-N, P, K, and Mg were high in order of P > K > Mg > NH_4-N > NO_3-N with the value of 5426.5, 3473.9, 1373.5, 1239.9, and 749.5 mg L^{-1}, respectively.

Table 1: Selected nutrients of the raw materials used for formulated liquid fertilizer

MATERIALS	ELEMENTS							
	pH	TOTAL (mg L^{-1})						
		NH_4-N	NO_3-N	P	K	Ca	Mg	Na
Laundry disposal water	8.2	770.6	476.3	334.3	13.9	22.1	3.67	2390.3
Vegetable waste	5.6	1239.9	749.5	5426.5	3473.9	10235	1373.5	226.4

Macro Nutrients Availability in Formulated Liquid Fertilizer

The pH (Figure 1) of liquid fertilizer formula T3 that acidic proved most suitable, compare to T1 and T2 that were slightly acidic. These results were similar to Cooper, (1975) who found that most liquid fertilizers suitable for agriculture production had pH solution in the range 5 to 6.5. Meanwhile, according to Phibunwatthanawong and Riddech, (2019) the suggested pH for liquid organic fertilizer is in range of

3 to 5. The pH of T3 was alkaline at the beginning of the study because of high in sodium content initially contain in the laundry disposal water (Wind, 2007). As the incubation process takes place, the bacteria and fungi start to digest the organic matter which then released organic acids. This will also leads to ammonium release as rapid degradation of organic acids occur and explains high pH obtained (Satisha and Devarajan, 2007). Then it turn to acidic starting at day 3 of incubation and remain the same throughout fermentation process. Since the bottles containing vegetables and laundry disposal water mixtures were sealed during incubation process, acid accumulation might cause the decrease of the pH with time (Hultman, 2009). The acidic pH values in T3 were low compare to T1 and T2 due to amount of vegetable waste used in T3 formulation was the highest in the study. Generally, due to pH of T3 remain the same after three days fermentation it indicated that the fermentation more than 3 days did not change the pH of T3 formulated liquid fertilizer.

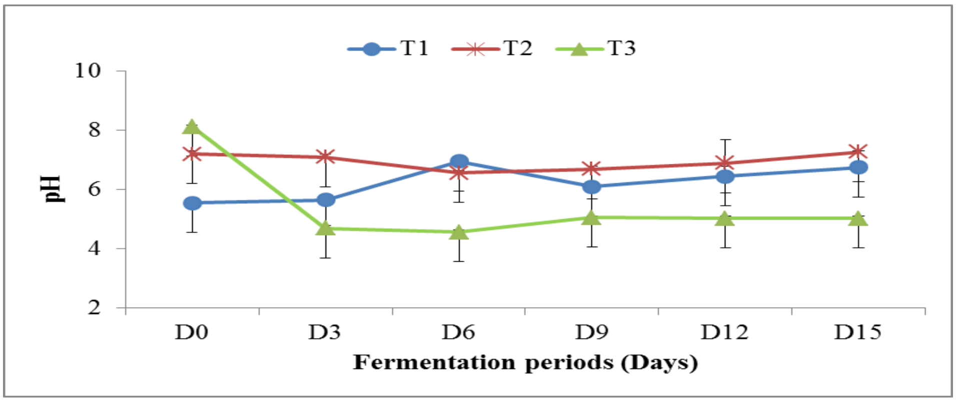


Figure 1: pH of formulated liquid fertilizers containing different ratios of vegetables waste with laundry disposal water

Ammonium decreased and nitrate formation (Figure 2) in the treatments occurred simultaneously. As the fermentation process takes place, mineralization process of organic matter by microorganisms as the microbe degraded the organic materials started in solution (Phibunwatthanawong and Riddech, 2019; Latifah *at el*., 2015). According to Makan et al. (2013), in case of N mineralization, it was generally higher under constant water content. Ammonia is known to be highly soluble thus inhibits ammonia to release from raw materials. Besides, nitrification process might also occur during fermentation that changed NH_4^+ into NO_3^-. This might be true for the decreased of NH_4^+ and increased of the NO_3^- content in formulated fertilizer solution. NO_3^- in the solution was detected as early as the 0 days after the start of fermentation process indicating that nitrification occurred immediately. Most of NO_3^- concentration in all treatments increased until days 9 of fermentation. Result showed that T3 treatment has highest NO_3^- concentration in liquid fertilizer formulation compare to others. The maximum concentration of NO_3^- in T3 treatment was attained on the days 3 of fermentation. Even thou, after day 3 until the end of fermentation for T3, NO_3^- concentration slightly increase yet, it was not significant different.

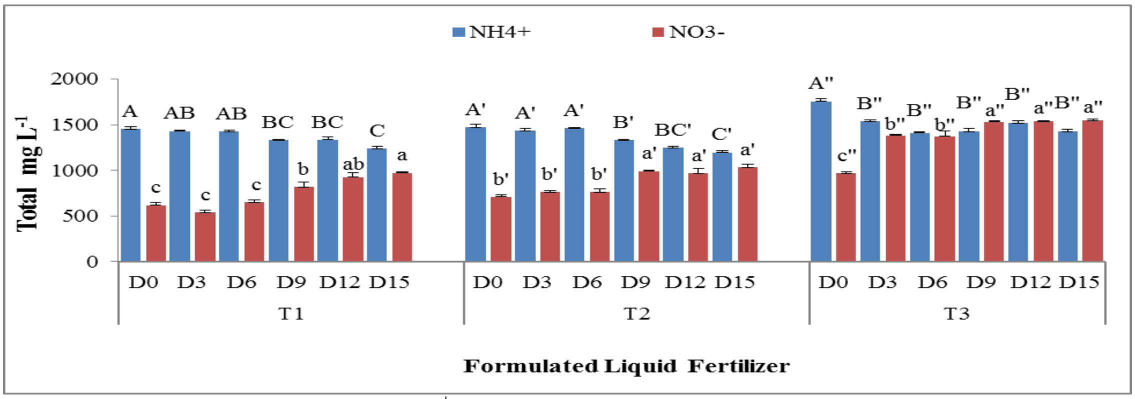


Figure 2: Effect of fermentation periods on total NH_4^+ and NO_3^- in formulated liquid fertilizer. Means with the same letters are not significantly different using Tukey's Test at p≤ 0.05. Means with uppercase letters represent NH4+ and means with lowercase letters represent $N0_3^-$. Bars represent the mean values ± SE.

Figure 3 and 4 shows the macro nutrient P, K, Ca, Mg and Na availability in formulated liquid fertilizers in various fermentation periods. Result shows that phosphorus contents was not significant different throughout fermentation periods except in T3 treatment. Phosphorus content extracted from T3 was highest compare to others treatment, which was range from 163.2 mg L^{-1} to 808.8 mg L^{-1} (Figure 3a). The P content in formulated liquid fertilizers was low compare in vegetables waste. Due rapid P released from animal manure and compost was followed by a slow rate as the desorption and diffusion of P limits the rate of P released in short and long term (Mc Dowell and Sharpley, 2003). Generally, increased fermentation periods and weight of vegetables waste will increase P content in formulated liquid fertilizers.

Lousier and Parkinson (1978) reported the release of potassium is usually faster as compared to other nutrients with highly mobile materials. Similarly with the Figure 3b, potassium occurred as the highest micro nutrient contents in formulated liquid fertilizers. Base on result, there were significant different were observed in T2 and T3 treatment toward fermentation periods. K content extracted from T3 was highest compare to others treatment, which was range from 3641.0 mg L^{-1} to 9385.0 mg L^{-1}. Generally increased fermentation periods and weight of vegetables waste will increase K content in formulated liquid fertilizers. The maximum concentration of K in T3 treatment was attained on the days 3 of fermentation.

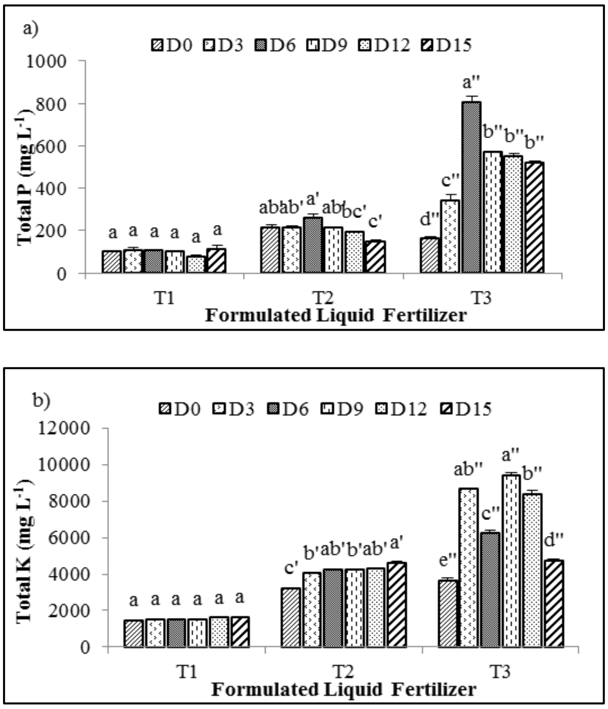
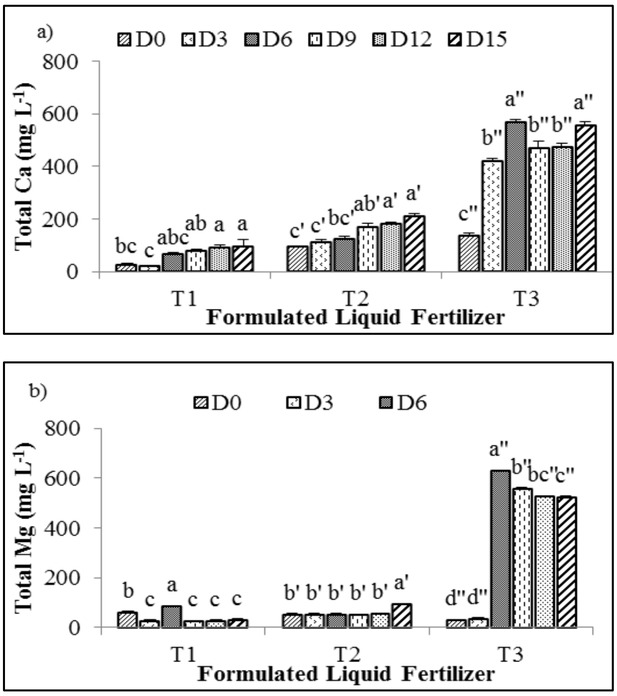


Figure 3: Effect of fermentation periods on; a) Total P and b) Total K in formulated liquid fertilizers. Means with the same letters are not significantly different using Tukey's Test at p≤ 0.05. Bars represent the mean values ± SE.

Results indicated that there was significant different on fermentation periods between T3 treatment with Calcium, all treatments with Magnesium and T1 and T3 treatment with Sodium content (Figure 4). Calcium content extracted from T3 was highest compare to others treatment, which was range from 1636.5 mg L^{-1} to 808.8 mg L^{-1} (Figure 4a). Meanwhile, magnesium content in T3 was also highest compare to others treatment, which was range from 29.75 mg L^{-1} to 628.5 mg L^{-1} (Figure 4b). Sodium content extracted from T3 was highest compare to others treatment, which was range from 1090.5 mg L^{-1} to 2414.5 mg L^{-1} (Figure 4c). Higher amount of Na in the formulated liquid fertilizer was attributed by laundry disposal water due to high sodium hydroxide based soaps and detergent commonly used in laundry (Morel and Diener, 2006).

Generally increasing the fermentation periods will affect pH, NH_4^+, NO_3^-, P, K, Ca, Mg and Na content in formulated liquid fertilizer. Moisture content which affects microbial activity as well as the physical structure in of organic substances may also influence the release of other important cations and P in formulated fertilizer solution. The size surface of vegetable wastes may also contribute to nutrients dissolution in water. By reducing the size surface of the materials, it can increase the area that is readily accessible for microbial activity (Hubbe, *et al.*, 2010). A nutrient solution is usually used in soilless cultivation for plant production. Table 2 summarizes the range of major nutrient concentration used or found satisfactory in liquid fertilizer for hydroponic solution for lettuce by range of researchers (Sanguandeekul, 1999). It indicated that the nutrients content in formulated liquid fertilizer was higher than the recommendation nutrient concentration. With this it can be dilute to achieve the suitable concentrations. However, the present of excessive sodium in formulated liquid fertilizer will resulted in discoloration and burning leaves. According to Stephen (2003) high level of sodium can cause some toxicity effects to certain plants as well as prevents calcium from reaching them.



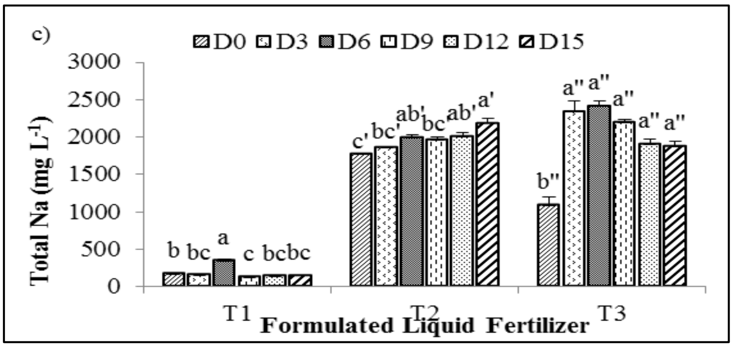


Figure 4: Effect of fermentation periods on; a) Total Ca, b) Total Mg and c) Total Na in formulated liquid fertilizers. Means with the same letters are not significantly different using Tukey's Test at p≤ 0.05. Bars represent the mean values ± SE.

Table 2: Concentration of nutrient ions (mg L^{-1}) used by various researchers for hydroponic lettuce growing

SOURCES	NO_3-N	NH_4-N	P	K	Ca	Mg
Perez Melian al., 1977	168	-	31	273	180	28.6
Cooper, 1977	200	-	60	300	170	50
Os & Kuiken, 1984	133	-	30.98	195	90	18
Voogt,1988	133	7	30	156-292	54-120	9-18
Bres & Weston, 1992	140	-	60	150-225	150	40
Kanaan & Economakis, 1992	159	-	36	320	167	63

CONCLUSION

Reuse of wastes as nutrient sources has become common practice in world. This study found that, K content in formulated liquid fertilizer was highest followed by Na, NH_4^+, NO_3^- , P, Ca and Mg, while pH of treatment mostly slightly acidic. It is coincided with the recommendation nutrient concentration of liquid fertilizer that requires high K concentration in their formulation such as Cooper, Voogt and Bres & Weston formulation. Result shows that increasing amount of the raw materials in the formulation able to increase the nutrient content in liquid fertilizer. This was better than to increase the volume of the liquid (wastewater) due to higher sodium content in it. Formulation with 1:5 of vegetables waste to laundry disposal water and 3 days incubation period give the best option to be further use as a liquid fertilizer as it contains the optimum K, NH_4^+ and NO_3^- content, adequate amount of P, Ca and Mg content that suitable to be used as a liquid fertilizer. In conclusion, laundry disposal water and vegetables waste has the potential to be used in formulating liquid fertilizer and may be beneficial to sustain agricultural production. Further study on crops production needs to be done to validate its potential as liquid fertilizer. It is also recommended to test heave metal elements content of this untreated wastewater in detail for food safety purposes.

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