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Characterisation of Liquid Fertiliser from Different Types of Bio-Waste Compost and its Correlation with the Compost Nutrients

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Liquid fertiliser contains nutrient compounds that could be applied as plant enhancer and are used in urban agriculture as it does not require soil medium and environmentally friendly. An organic liquid fertilizer can be produced from bio-wastes composting as it contains more organic nutrients that are essential to promote healthy plant growth. Liquid fertiliser can be collected during the composting process (compost leachate) or by mixing compost with a certain solution (compost tea). Both the end solid and liquid fertilizer compost could be commercialised as organic fertilisers. Although there are a lot of studies regarding the nutrient characteristic of the end product compost and liquid fertiliser, the correlation of nutrient composition between liquid fertiliser and solid compost is unclear. The variation of waste input creates an unclear nutrient range of end compost in both solid and liquid products. This study aims to develop a correlation between the nutrients available in the liquid fertilizer (both compost leachate and compost tea) with regards to the nutrients available in the end solid compost from different bio-waste source. Based on the physical and nutrient characterisation, liquid fertiliser contains elements such as nitrogen (N), potassium (K) and phosphorus (P) that are essential for plant growth. Due to high organic content in the liquid fertiliser, dilution or pre-treatment is needed to avoid plant and soil damage. By using a graphical analysis and simple linear regression model, a formula can be developed to predicting the nutrient composition of the compost products. The formula allows predicting the nutrient composition of the compost by analysing the liquid fertiliser and save the cost and time of the analysis.

1. Introduction

Urban agriculture is an industry located in an urban area, which produces, processes and distributes a diversity of food in and around the urban area (Mougeot, 2000). Due to low soil quality and limited land, urban communities tend to use liquid fertiliser as an alternative to conventional fertiliser. Liquid fertiliser can be adjusted freely according to the nutrient requirement of different crops and is environmentally friendly as it possesses a lower risk of soil contamination and human health. The organic liquid fertiliser is being used as an alternative as it contains nutrient compounds that are essential for plant growth and helps to reduce nutrient fluxes compared to mineral fertilizers (Anik et al., 2017). Organic liquid fertiliser can be obtained as a by-product of bio-waste compost. Compost involve the degradation of complex organic materials into simpler constituents by indigenous microbes (Fan et al., 2017). Compost liquid fertiliser could serve as biostimulation to improve crop yield and quality, suppress plant pathogenic microorganisms, supply the plant with water-soluble nutrients and enrich the soil with the microorganism (Mohamed et al., 2015). Compost liquid fertilizer is rich in potassium

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(K), magnesium (Mg), calcium (Ca), sodium (Na), and various microelements (Jarecki et al., 2005). It contains humic acids, which can regulate the micronutrient and macronutrient absorption (Atiyeh et al., 2002). The liquid fertiliser compost can be obtained in a form of leachate (CL) or can be produced by mixing the compost with a certain solution to obtain a liquid extract called compost tea (CT). Compost solid and liquid fertiliser produced from bio-waste should be commercialized as an organic fertilizer (Zaller, 2006).
Although the study on a nutrient characteristic of compost products (solid and liquid) are clear, a correlation of nutrient content in the compost solid fertiliser and the respective liquid fertiliser is still not fully researched. Different input composition of bio-waste will form different nutrient values in the end composts.
This research aims to characterise the nutrient content of the liquid fertiliser from different bio-waste source and its end compost and develop a correlation of nutrients between solid and liquid compost fertilizer. Analyses of solid compost sample is more complicated than liquid fertiliser. The solid compost is heterogeneous and the analyses would require extra sample extraction step (usually using KCl or Ca2Cl) that is time consuming and results in higher standard deviations in the nutrient values. Measurement of liquid fertiliser which is homogeneous and do not require the extraction step is favourable. Development of such correlation, i.e. to predict the nutrients values in the compost based on those present in the CL, could save the cost and time for evaluating the quality of the compost. Developing the correlations will create a clear nutrient range of the liquid fertiliser and compost from different bio-waste source.

2. Materials and methods

2.1 Literature search and keywords

Most of the previous work done is focused on the nutrient characterization of the end compost products (liquid and solid), however, the nutrient correlation studies between the two products are still unclear. In this study the physical and nutrient characteristics of the liquid fertilizer will be reviewed from 3 main bio-wastes, namely municipal waste (MSW); consist of landfill and domestic waste, animal waste; consist of manure from livestock such as goats, cows and chicken, and green waste; consist of lawn clippings, grasses, green leaves of vegetables, herbs and plant materials.
The major nutrients considered are nitrogen (N), phosphorus (P) and potassium (K). All of the MSW in the literature are collected from the recycling or composting centre and the CL are collected from the leachate runoff pond. The animal and green waste based compost and CL are collected from the medium scale vermicompost site. For CT, the extraction technique of the compost is limited to water as the extractant; the method of the extraction used are aerated extraction technique. A range of published data for compost and liquid fertiliser nutrients are extracted from the peer-reviewed international journals.
The relationships between the FW compost and liquid fertiliser can be addressed through a simple linear regression shown in Eq(1):

$$Y = mX \tag{1}$$

m is the nutrient correlation value, X is the nutrient value of compost (g/kg) and Y is the nutrient value of the liquid fertilizer (mg/L). A graph of the nutrient composition of compost vs nutrient composition of liquid fertilizer (CL or CT) will be plotted and used for correlation analysis. From the graph, the model to predict the nutrient composition will be generated based on the simple linear regression model. m is equivalent to the slope of the graph and X and Y are represented as variables. Each nutrient composition will have its own correlation equation. The graphs are plotted using Microsoft Excel 2010.

3. Results and discussion

3.1 Physical characterization of compost based liquid fertilizer and the nutrient composition of the compost products from different bio-waste

The physical and nutrient characterization is important in determining if the compost products are suitable to be applied as a fertilizer. Table 1 shows the physical characterization of liquid fertilizer from a different type of compost.
Based on Table 1, liquid fertiliser from MSW contains the higher COD range of 55,689 – 105,300 mg/L compared to liquid fertiliser from animal waste (6,542 – 100,000 mg/L) and a rather low range for green waste, 1,152 mg/L. The high COD value in the liquid fertiliser compost is due to the organic matter content in the liquid (Mokhtarani et al., 2012). The high COD contributes to the low pH in the leachate. The high COD and low pH in the liquid fertiliser can damage the plant and treatment is crucial. Treatment with microbial inoculation and long storage can reduce the COD level and stabilize the pH (Zhou et al., 2010).

Table 1: Physical characteristic of liquid fertiliser from different compost bio-waste.

Bio-waste source	COD (mg/L)	pH	TSS (mg/L)	EC (dSm-1)	References
Municipal solid waste (MSW)	-	8.0	-	12.6	Jarecki et al., (2012)
	55,689	-	-	-	Liu et al., (2015)
	65,000 ± 5,000	3.8–6.3	15,961–33,682		Liu et al. (2010)
	105,330 ± 2,577	4.9 ± 0.2		28.9 ± 1.4	Bakhshoodeh et al. (2017)
Animal waste	-	8.4	3,176	2.80	Cáceres et al., (2015)
	100,000 ± 20,000	7.4 ± 0.2	6,050 ± 1,000	-	Neshat et al. (2017)
	6,542 ± 291	-	-	3.84	Markou et al., (2016)
Green waste	1,152 ± 36	8.79 ± 0.02	180 ± 9	5.05 ± 0.05	Tyrrel et al. (2008)

Based on Table 2, different bio-waste contains a different range of nutrient composition. Compost based from animal waste has a highest N and P content of (6.1 – 25 g/kg for N) (1.8 – 6.4 g/kg for P). Green waste recorded a highest K value with a range of 5.1 – 19 g/kg. In terms of CL, animal waste-based CL recorded the highest nutrient range of N and P (800 – 900 mg/L of N), (170 – 600 mg/L of P). CL from green waste contains a higher range of K compare to animal waste with a range of 500 – 1,080 mg/L. MSW recorded the lowest nutrient composition of compost and CL. This is due to lack of non-organic components present in the bio-waste.

Table 2: Nutrient composition of the CL and compost from different bio-waste

Biowaste source	product	N	P	K	References
		g/kg for compost and mg/L for CL			
Municipal Solid Waste (MSW)	Compost	1.03 ± 0.070	0.10 ± 0.001	4.16 ± 0.036	Jarecki et al. (2012)
	CL	-	0.4	320 ± 60	
Animal waste	Compost	6.80 ± 0.1	6.40 ± 0.3	7.20 ± 0.5	Tejada et al. (2008)
	CL	900 ± 200	500 ± 200	600± 200	
	Compost	25.00	1.80	-	Gutiérrez-Miceli et al. (2008)
	CL	-	170 ± 10	834	
	Compost	6.1	5.9	6.8	Singh et al. (2010)
	CL	800	600	600	
Green waste	Compost	5.3 ± 0.2	4.1 ± 0.2	5.4 ± 0.3	Tejada et al. (2008)
	CL	700± 200	400 ± 100	500 ± 100	
	Compost	-	-	19	Ávila-Juárez et al. (2015)
	CL	-	-	1,080	
	Compost	4.9	4.4	5.1	Singh et al. (2010)
	CL	700	400	500	

Table 3 shows the nutrient composition of compost and CT from different bio-waste.

Table 3: Nutrient composition of the CT and compost from different bio-waste

Biowaste source	product	N	P	K	References
		g/kg for compost and mg/L for CL			
Municipal Solid Waste (MSW)	Compost	23.3	-	5.6	Hargreaves et al. (2009)
	CT	138	-	443.83	
	Compost	12	9.7	5.662	Hirzel et al. (2012)
	CT	199	0.27	64	
Animal waste	Compost	24.80	28.10	21.10	Pant et al. (2012)
	CT	293	14.8	1120	
	Compost	21.5	41.6	1.40	Khan et al. (2015)
	CT	-	17	200	
	Compost	-	23 ± 2	7 ± 1	Pant et al. (2009)
	CT	-	16	180.4	
Green waste	Compost	-	3.9	14.4	St. Martin et al. (2012)
	CT	-	100	60.22	

The CT animal waste based recorded the highest N and K content with a value of 293 mg/L for N and 116 – 1,120 mg/L for K. CT from green waste recorded the highest P content with a value of 100 mg/L, which are 2 - 3-fold higher compare to animal waste CT.
Despite the high nutrient value of the compost in Table 3, the overall nutrient composition of CT is lower compared to CL recorded in Table 2. During composting process, leachate is produced due to the activities of micro-organism and some of the nutrients from the compost are loss through leaching (Singh et al., 2010). CT is extracted from an end-product compost where the soluble nutrients are already leached.

3.2 Correlation of nutrient between liquid fertilizer and compost fertiliser

Figure 1, 2 and 3 show the graph of the nutrient correlation between liquid fertilizer (CL and CT) and compost fertiliser. From all three figures, the nutrient composition of the compost is directly proportional to the nutrient value of the liquid fertiliser. The value of *m* from the compost vs CL (133.83 for N, 90.685 for P and 66.787 for K) is higher compared to the value of the compost vs CT (9.8852 for N, 0.4752 for P and 43.640 for K). From the m value obtained, a formula to predict the nutrient value of the product can be generated.

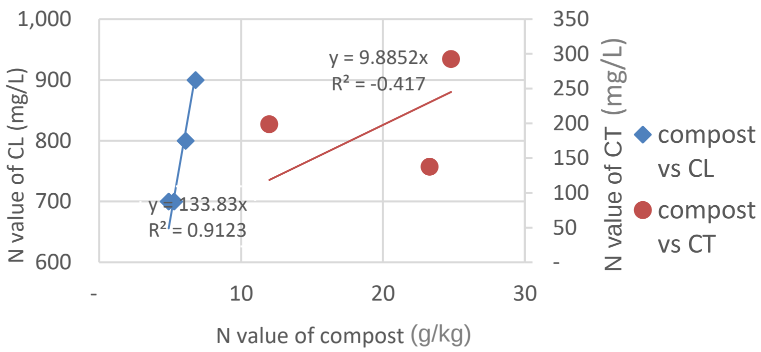

Figure 1: N correlation between compost and liquid fertiliser

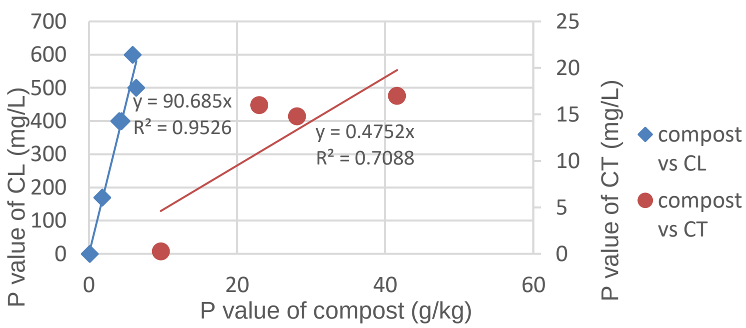

Figure 2: P correlation between compost and liquid fertilise

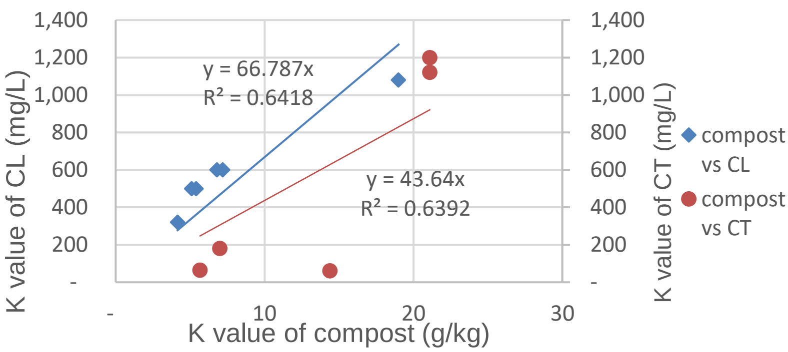

Figure 3: K correlation between compost and liquid fertiliser

Table 4: Correlation formula of each nutrient for CT and CL

Nutrient composition	Nutrient correlation value (m)		Formula	
	CL	CT	CL	CT
N	133.83	9.8852	Y = 133.830X	Y = 9.8852X
P	90.685	0.4752	Y = 90.685 X	Y = 0.4752X
K	66.787	43.558	Y = 66.787X	Y = 43.640X

4. Conclusion

Based on the physical and nutrient characterisation, liquid-based fertiliser is a potential compost product that can be used as an organic liquid fertiliser. Dilution or pre-treatment is recommended as the product contains high organic compounds ranging from 1,152 mg/L to 105,300 mg/L that can damage the plant and soil. Each biowaste contains a certain amount of nutrient range. Animal waste compost recorded the highest N and P composition which can reach as high as 25 g/kg for N, 6.4 g/kg for P. Green waste compost recorded the highest K value with maximum value of 19 g/kg. Based on the nutrient correlation graph, the nutrient composition of compost is directly proportional to CL and CT. The N, P and K nutrient value for CL is 124 fold, 90 fold and 23 fold higher compare to CT. The nutrient correlations between compost and its liquid-based fertiliser obtained in this paper are based on the literature and a real case study must be done to obtain more accurate correlations. The nutrient range and correlation are significant in determining the range of the compost products based on the type of waste and predicting the nutrient value and reducing the analysis cost.

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