Comparative Study on the Degradation of Sugarcane Bagasse and Banana Stem Using Vermicomposting by *Eudrillus eugeniae*

Afifah Baharuddin, University of Malaya, Malaysia

Fauziah Shahul Hamid, Agamuthu Pariatamby, University of Malaya, Malaysia

CONTACT

Afifah Baharuddin
Institute of Biological Sciences,
Faculty of Science,
University of Malaya,
50603 Kuala Lumpur, Malaysia
Tel: +6017-6969747
E-mail: afifahbaharuddin@gmail.com

EXECUTIVE SUMMARY

This study is to test the practicability of vermicomposting of sugarcane bagasse and banana stem using *Eudrillus eugeniae* (African nightcrawler) and also to determine the rate of degradation of each waste. Fresh sugarcane bagasse (SCB) was mixed with soil at five different ratios namely 1:9, 1:4, 3:7, 2:3 and 1:1. These mixtures were then introduced with ten *Eudrillus eugeniae* in each container. This procedure was repeated for the banana stem as well. The vermiculture from each treatment were analysed for conductivity, ORP, TDS, C/N ratio, salinity and pH. The results obtained indicated that all mixture of SCB was completely degraded after 42 days wherelse it took 21 days for the complete degradation of banana stem. The fastest degradation was observed for the ratio of 1:9 which was 14 days for SCB and 10 days for banana stem. The degradation rate via vermicomposting was 2.38×10^{-3} kg per day for sugar cane bagasse and 4.76×10^{-3} kg per day for banana stem. This study indicate that banana stem has better degradation properties using *Eudrillus eugeniae* compared to SCB in the ratio of 1:9. It can be concluded that the best ratio for vermicomposting of both SCB and banana stem was 1:9.

INTRODUCTION

In Peninsular Malaysia, a total of 4.2 million metric tons of crop residue and 2.3 million metric tons of livestock waste were produced in 2006 (Rahimah, 2007). Agricultural waste from livestock farms and pesticides and fertilizers constitute the second highest source of organic pollutants polluting our rivers and coastal waters, second only to sewage (Rahimah, 2007). From 1986 to 1990, agricultural waste contributed 13 percent of the total BOD pollution load (Greenpages, 2006).

Since there is an increase in the proportion of recyclables in the waste stream such as organic wastes, it calls for better recovery, reuse and recycling (Adi Ainurzaman, 2008). In relation to waste management issues, it recommended that better solutions should consider practical and economical way to optimize the utilizations of any MSW before being sent for disposal (Azni Idris et al., 2004).

Sugarcane bagasse is a residue produced in large quantities by sugar industries. In general, one metric ton of sugarcane bagasse generates 280kg of bagasse, the fibrous by-product remaining after sugar extraction from sugar cane (Sun et al., 2004). However the utilization of sugarcane bagasse is still limited and is mainly used as a fuel to power sugar mill (Antaresti et al., 2002; Charles and Shuichi, 2003).

The total planted area of banana in Malaysia reached 33,704.2 ha in 2001 (Abdul Khalil et al., 2006). Banana plant being normally tall and fairly sturdy, often erroneously referred to as a ‘‘tree’’. It is a large herb, with succulent, very juicy stem which is a cylinder of leaf-petiole sheaths composed of long fibres and strongly overlapping called pseudostem (Asia Source, 1998). Moreover, many people are not aware of the fact that after each banana plant gives forth its fruit; its banana-producing days are over (Ramirez, 1995).

Vermicompost is the end product of vermicomposting of organic material which is rich in humus and nutrients. It is the cast excreted by the earthworms after the organic material is digested in the gut of earthworms (Hand et al., 1998). Vermicompost is a nutrient rich, natural fertilizer and soil conditioner. As reported by Aranda et al., (1999) vermicompost is stable and homogeneous; has desirable aesthetic; may have reduced levels of contamination and furthermore, is a valuable, marketable and superior plant growth medium. During this process, important plant nutrients such as N, P, K, Ca, etc. present in the waste are converted into the forms that are much more soluble and available to plants than parent substrates (Ndegwa and Thompson, 2001).

The earthworm species used in this study is *Eudrillus eugeniae* (African Night Crawler). *Eudrillus eugeniae* is commonly referred to as the African night crawler, occurs all over the world but mostly in West African regions (Shagoti 1985; Segun 1998). Esther Rani et al. (2007) found that *Eudrillus eugeniae* is capable of ingesting and excreting organic materials at a high rate as they eat 10% soil 90% organic waste materials; convert the organic waste into vermicompost faster and have the ability to tolerate temperatures ranging from 0 to 40˚C.

The essentials of vermicompost are proven in earlier studies (Dominguez et al., 1997) and include source of plant nutrient, plant growth promoting activity, improving crop growth and yield, reduction in soil C/N ratio, recycling of nitrogen in cycle, and improving soil physical, chemical and biological properties. The end product from the vermicomposting process which is organic waste was a homogenized, dark brown and odorless material. This happened because of the variety of soil decomposing organisms and detritus feeding invertebrates especially earthworms which have recycled organic waste (Oyedele et al., 2005). Therefore, this study, focused on practicability of vermicomposting of sugarcane bagasse and banana stem using *Eudrillus eugeniae* (African nightcrawler) and also to determine the rate of degradation of each waste.

METHODOLOGY

Vermicomposting Treatment Preparation

Sugarcane bagasse and banana stem were weighed and recorded. The waste was further chipped into smaller pieces to reduce its size to enable faster consumption and degradation by the worms. 40 containers (25cm × 15cm × 20cm) were filled with 1kg mixture of the desired waste and soil at 5 different ratios. Ten worms with the average size of 5.5cm were introduced into each of the containers. The volume of goat dung used for this experiment were kept constant at 1gm wherelse the treatment ratios are as presented in Table 1 below;

Table 1: Experimental setup of the vermicomposting system

Waste	Experiment	Waste to Soil Ratio	No of Worms Added
Banana stem	N	9:1	10
	O	8:2	10
	P	7:3	10
	Q	6:4	10
	R	5:5	10
Control	NC	9:1	-
	OC	8:2	-
	PC	7:3	-
	QC	6:4	-
	RC	5:5	-
Sugarcane bagasse	F	9:1	10
	G	8:2	10
	H	7:3	10
	I	6:4	10
	J	5:5	10
Control	FC	9:1	-
	GC	8:2	-
	HC	7:3	-
	IC	6:4	-
	JC	5:5	-

Physiochemical analysis

The experimental setup was monitored for parameters including pH, conductivity and salinity which were conducted by YSI multipurpose probe meter. Chemical analysis was conducted to determine the TOC and total nitrogen using CHN Analyzer model Perkin Elmer 2400 series II. Mixture samples were digested using acid-digestion procedures and subsequently analyzed for metal concentration using Induced Couple Plasma-Atomic Electrospectrophotometry (ICP-AES).

Data generation and evaluation

The individual measurements and readings obtained from the monitoring were compiled. Subsequently, the growth rates of the worms were calculated using the total worm biomass obtained during each weekly monitoring. The following formula was used to determine the growth rate (Suthar, 2005).

$$\text{Growth rate determination, } R = (N2-N1)/T$$

Where, R = Growth rate
N1 = Initial worm biomass (gm)
N2 = Final worm biomass achieved (gm)
T = Period of the experiment

RESULTS AND DISCUSSION

Number of worms

Banana stem and sugarcane bagasse took about 5 and 6 weeks respectively for complete degradation. The data recorded for each week during the vermicomposting process are presented in Figure 1 and Figure 2.

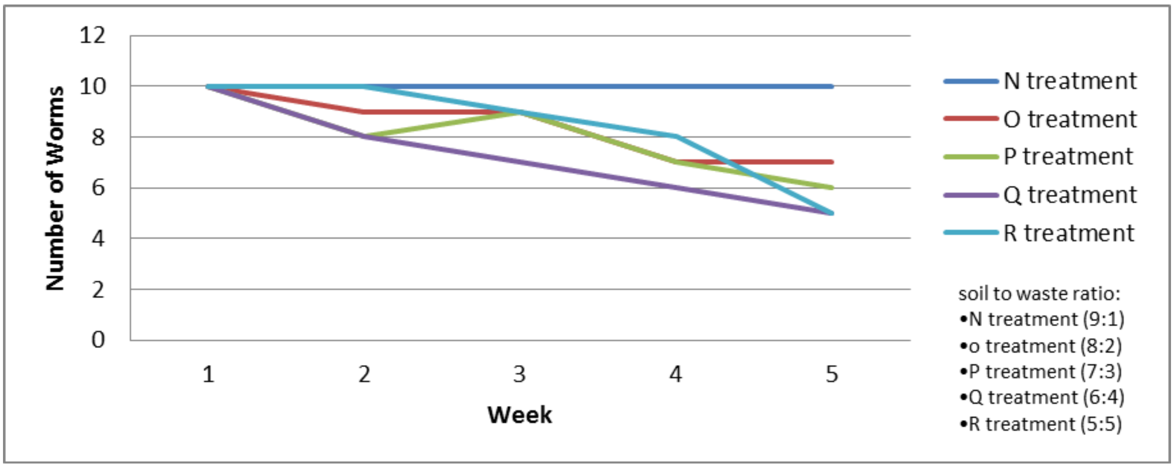

Figure 1: Number of worms in banana stem set-ups

Treatment with 60% soil : 40% waste ratio recorded the highest mortality of the worms. This differs from the other treatment of banana stem; N (treatment 9:1), O (treatment 8:2), P (treatment 7:3) and R (treatment 5:5) treatment while the N treatment shows consistent mortality rate which is 10 numbers of worms for each week.

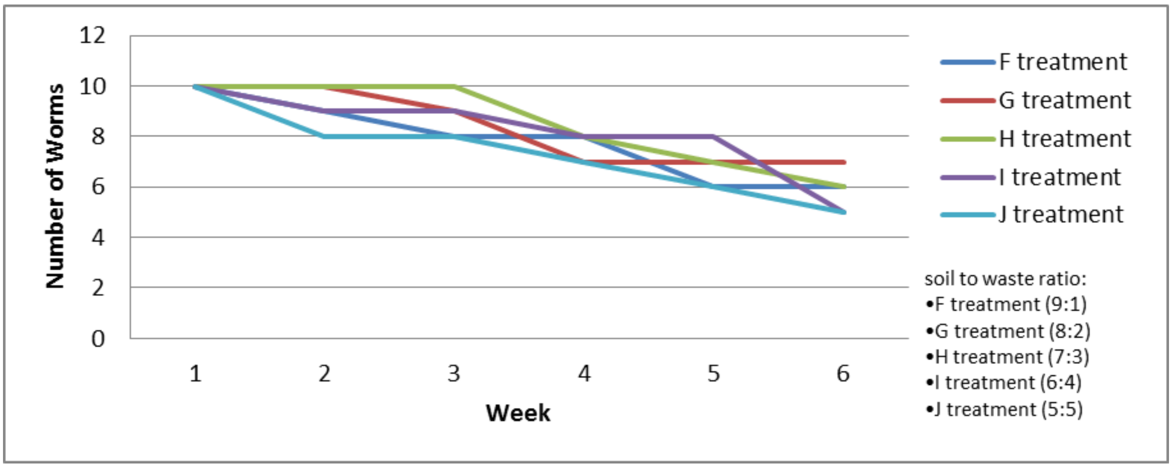

Figure 2: Number of worms in sugarcane bagasse set-ups

However, the treatment with sugarcane bagasse was very different from banana stem (Figure 2). H treatment (7:3) shows a consistent number of worms until the third week then finally it starts to decrease. After week 3, all the treatments with sugarcane bagasse show decreasing number, because the nutrient in the waste probably was diminishing due to complete degradation.

The decreasing number of worms in the waste mixture can be related to poor water retaining capacity of the waste. This goes to I treatment (6:4) and J treatment (5:5), both of this waste mixture contain high amount of soil and less waste. However P (treatment 7:3) mixture shows increasing number of worms during week 3 compared to J (treatment 5:5) mixture that drastically decreasing from the beginning of the experiment. Sugar cane bagasse cannot retain more water compared to banana stem due to the excess of fiber content in the sugarcane bagasse.

pH Value

Figures 3 and 4 show pH value and their changes in each treatment using banana stem and sugarcane bagasse respectively. All treatments maintained their pH in the range of pH 6.0 to 7.0. This helped the survival rate of the worms because pH of neutral is required for the optimum growth of worm.

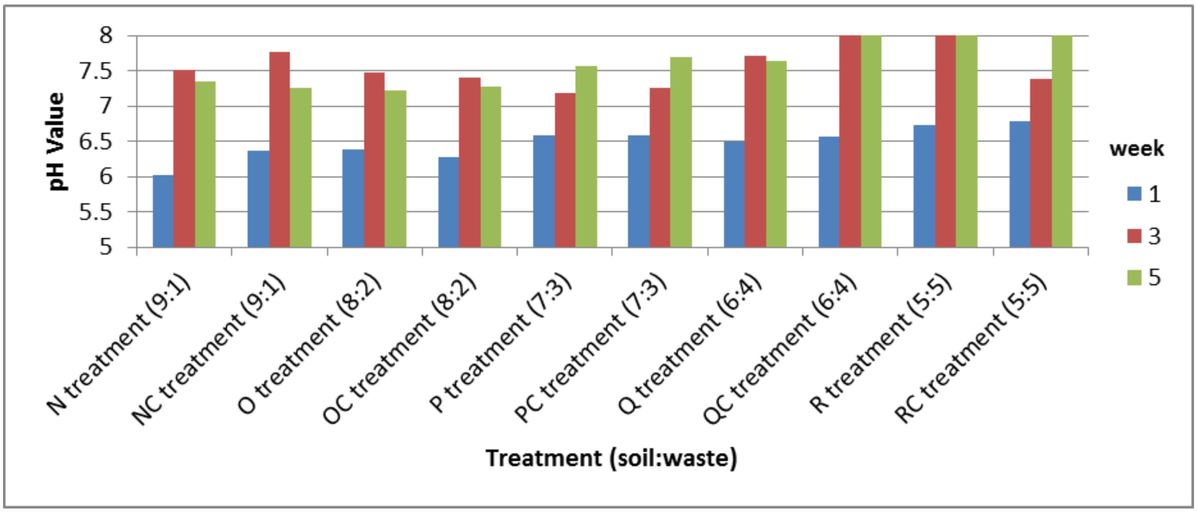

Figure 3: pH distribution in banana stem set-ups

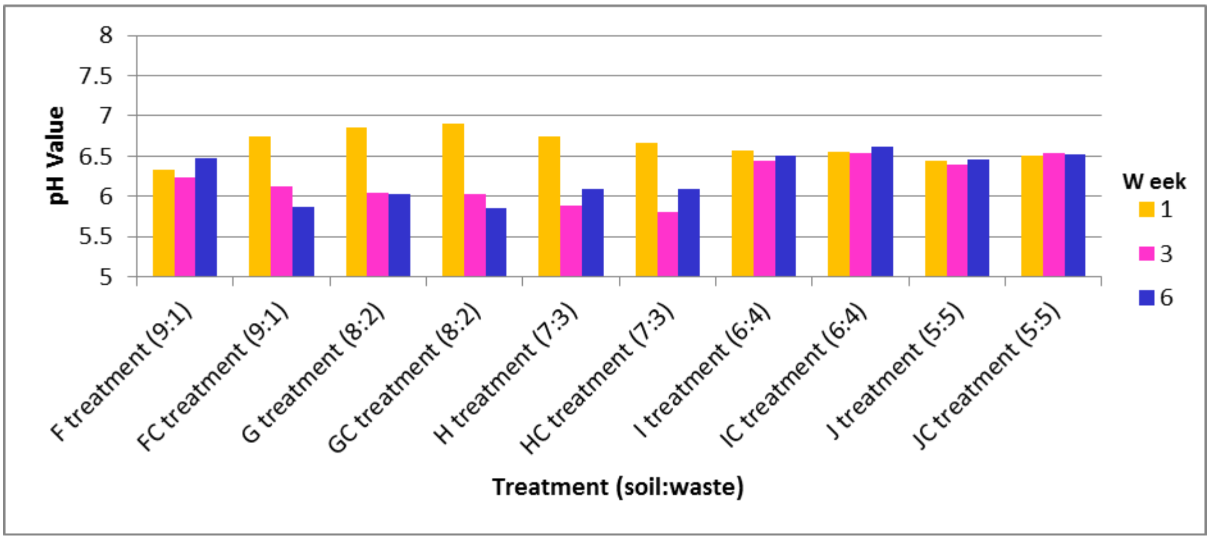

Figure 4: pH distribution in sugarcane bagasse set-ups

Recent study by Hou et al., (2005), the pH for vermicomposting process was in the range of 6.5 to achieve preferable pH condition. If the pH is lower than or exceeded this range, the number of earthworm will decrease (died). Figures 3 and 4 show variation of pH in certain treatments. Ndegwa and Thompson (2001) stated that, due to the mineralization of nitrogen and phosphorous into nitrites/nitrates and orthophosphate and bioconversion of the organic material into intermediate species of organic acids, it caused the decrease in pH values in the treatments.

C/N Ratio

Table 2 shows the chemical characteristics of vermicompost of banana stem while Table 3 is the chemical characteristics of vermicompost of sugarcane bagasse. The C/N ratio for banana stem at day zero was averaged at 32, but decreased after reaching 21 days to give an average of 14. Sugarcane bagasse has its initial C/N ratio of 30 on day zero and was 16 after reaching 42 days. This indicates that the presence of worms in the treatment enhanced the waste degradation since organic C being utilized by the worms as nutrient for their metabolic activity. Thus, total C content drastically reduced at day final which were 21 days for banana stem and 42 days for sugarcane bagasse compared to control treatment. The ideal ratio for final compost should be 15. If C/N ratio of compost is more than 20, it is unavailable for the crop until the ratio is below (Agamuthu, 2004). According to Crawford (1983), N content in vermicompost is depends on the degree of decomposition and the initial N exist in the feed stock (bedding material). Overall, banana stem has the higher possibility to serve as organic fertilizer compared to sugarcane bagasse because banana stem showed lower C/N ratio which was below 15 at the end of vermicomposting process (Munroe, 2004).

Table 2: Chemical Characteristics of Vermicompost of Banana Stem

Parameter / Treatment		C/N ratio		P mg/kg		K mg/kg	
		Initial Day	Final Day	Initial Day	Final Day	Initial Day	Final Day
N	(9:1)	36.83	15.25	3.92	4.35	4.68	5.12
NC (control)	(9:1)	35.27	30.34	3.89	4.05	4.50	4.60
O	(8:2)	34.15	14.29	4.01	4.52	4.75	5.28
OC (control)	(8:2)	33.96	29.09	3.95	4.12	4.67	4.71
P	(7:3)	31.66	14.14	4.12	4.72	4.84	5.49
PC (control)	(7:3)	30.27	27.23	4.07	4.19	4.77	4.82
Q	(6:4)	29.45	14.75	4.21	4.86	4.95	5.59
QC (control)	(6:4)	30.63	27.67	4.16	4.25	4.89	4.91
R	(5:5)	27.95	13.02	4.32	4.95	5.10	5.75
RC (control)	(5:5)	28.12	26.33	4.29	4.36	4.97	5.07

P value

Generally, P for banana stem at initial day is about 4.12mg/kg and it increased to 4.68mg/kg. Sugarcane bagasse has its average about 2.86mg/kg for initial day and average of 3.49mg/kg at final day. The R treatment which soil to ratio is 5:5 shows the highest amount of P than other treatments. Due to the reaction by the worms, the available P in vermicomposting treatment increased which may affect the phosphorous mineralization in waste. This result is to the previous studies of which the end products of vermicomposting enrich with more available forms of plant nutrients (Suthar and Singh, 2008). During vermicomposting process, the worms convert the insoluble P into soluble forms with the help of P-solubilizing microorganisms through phosphatises that present in the gut and making it more available to plants (Suthar and Singh, 2008; Padmavathiamma et al., 2008; Ghosh et al., 1999).

Table 3: Chemical Characteristics of Vermicomposting of Sugarcane Bagasse

Parameter / Treatment		C/N ratio		P mg/kg		K mg/kg	
		Initial Day	Final Day	Initial Day	Final Day	Initial Day	Final Day
F	(9:1)	39.13	19.65	3.57	4.14	4.21	4.82
FC (control)	(9:1)	36.15	27.22	3.45	3.51	4.14	4.20
G	(8:2)	33.62	16.37	3.29	4.23	4.52	4.96
GC (control)	(8:2)	31.12	26.24	3.18	3.32	4.31	4.48
H	(7:3)	30.30	15.35	3.64	4.48	4.74	5.10
HC (control)	(7:3)	31.87	25.45	3.57	3.66	4.42	4.59
I	(6:4)	26.13	15.20	3.78	4.59	4.88	5.28
IC (control)	(6:4)	29.15	22.84	3.65	3.72	4.53	4.65
J	(5:5)	22.62	14.03	3.89	4.79	4.97	5.42
JC (control)	(5:5)	23.12	19.87	3.73	3.82	4.67	4.79

K value

From Table 2, average of K value for banana stem vermicomposting was 4.86mg/kg at the initial day. The values increased after reaching the final day with average 5.45mg/kg. Sugarcane bagasse has its initial at average of 4.66mg/kg while at the end of the final day was at average of 5.12mg/kg. All of the control treatments have low K. The banana stem contain high potassium to be present in the soil besides it is a high organic content waste. Edward and Lotfy (1972) also stated that K was higher in the final product than in the initial feed substrates indicating that the microbial flora influenced the level of available potassium.

CONCLUSION

As conclusion, banana stem and sugarcane bagasse can be degraded via vermicomposting using *Eudrillus eugeniae* even though there are differences in the degradation rate. Degradation rate differs with different types of organic waste used, which is 4.76 x 10^{-3} kg per day for banana stem and 2.38 x 10^{-3} kg per day for sugar cane bagasse. More fine in the structure of organic waste, faster the organic waste degraded. Structure of banana stem itself is small compared to sugarcane bagasse even though sugarcane bagasse were shredded into a small pieces.

In comparison to banana stem, sugarcane bagasse provided nutrients to the worms and have lower moisture content. However, it is still the best option to do vermicomposting due to its ability to degrade faster and having lower C/N ratio and able to maintain its pH throughout the vermicomposting process. Thus, the end product of vermicomposting sugarcane bagasse can be used as a fertilizer and reduce the percentage of agricultural waste being dumped into the landfill.

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