Waste to Value Added Product: Vermicomposting of Sugar Cane Bagasse and Leaves Using African Nightcrawlers (*Eudrillus Eugeniae*)

Shamini Krishnan, *University of Malaya, Malaysia*

Fauziah Shahul Hamid, Emenike Chijioke Uche,
Muhammad Hafiz Mahamad Rasid, University of Malaya, Malaysia

CONTACT

Shamini Krishnan

Institute of Biological Sciences,

Faculty of Science, University of Malaya, 50603

Kuala Lumpur, Malaysia

Tel: +603 7967 4632

Mobile: +6017 3213034

shamini_krishnan@live.com.my (corresponding author)

EXECUTIVE SUMMARY

The high volume of waste dumped per day leads to serious environmental issues. Among the issues is the generation of methane via anaerobic degradation of waste that contributes towards global warming. There are numerous options in minimizing organic waste disposed into landfills. This includes composting, recycling and vermicomposting. This study is aimed to investigate the possibility of treating sugar cane leaves and bagasse via vermicomposting by using *Eudrillus eugeniae* (African night crawler) worms. Therefore, the study compared degradation potential between sugar cane bagasse and leaves. Each of sugar cane bagasse and leaves were mixed with soil at selected waste to soil ratios namely 9:1, 7:3 and 1:1. Ten *Eudrillus eugeniae* with an average weight of 2.5±0.1g were added to each experimental set-up excluding the control. The result indicated that active burrowing potential of the worm into the soil was able to degrade the sugar cane leaves and sugar cane bagasse within 5 weeks and 6 weeks respectively. Also, the 1:1 treatment showed greater reduction of waste with increasing number of worms as compared with 9:1 treatment. Estimated degradation rate via vermicomposting was ±9.09 x 10^{-2} kg per day for the sugar cane leaves and 7.14 x 10^{-2} kg per day for sugar cane bagasse. The sugar cane bagasse and leaves are highly potential to degrade via vermicomposting but sugar cane leaves showed a better result to compost in a shorter duration compared to bagasse. Also, the vermicomposting of sugar cane bagasse and leaves using *Eudrillus eugeniae* in the ratio of 1:1 can be a better tool to divert the organic component from waste stream; to minimize the volume of waste disposal into landfill and produce the value added compost as the final product.

INTRODUCTION

Over the last few years, the problem of efficient disposal and management of organic solid wastes has become more rigorous due to rapidly increasing population, intensive agriculture and industrialization. Several food products are prepared in industrial units using agriculture goods/by products as raw materials (Suthar *et al*., 2010). The raw materials are processed through several industrial mechanisms to convert it into the final consumer items. During this process a considerable amount of liquid as well as solid waste is generated. Such agro-industrial sludge/wastes not only spoil the aesthetic sense of local habitats but at the same time also create environmental pollution, if proper disposal and management policy is not adopted. Under these situations it is advisable that waste products of one industry should be investigated with an objective to be used as raw material for other industry to produce value added product (Singh *et al*., 2010). Sustainable waste management practice is necessary to keep the environment clean. Production of large quantities of organic waste all over the world poses major environmental (offensive odors, contamination of ground water and soil) and disposal problems (Edwards and Bater, 1992). Therefore, the disposal of different types of wastes has become very important issue for maintaining healthy environment (Senapati and Julka, 1993).

Agricultural production in Malaysia continued to record positive growth from 2000 to 2005 and had expanded more in 2010 consistent with the government policies (Chuah *et al*., 2006).More than 2 million tonnes of agricultural waste are produced annually. It is either burned or dumped as waste and are great environment threat, causing damage to the land and the surrounding area in which it is dumped (Agamuthu, 2004). Agro waste is defined as waste produced as a result of various agricultural operations (Agamuthu, 2009). Among the agro-waste which has been disposed are sugar cane bagasse and leaves.

For the effective utilization of sugar cane wastes, there are considerable economic interests in the technology and development processes for better waste management (Zhang *et al.*, 2000). As a result emphasis is now on aerobic composting, that converts wastes into organic manure rich in plant nutrients and humus (Singh and Sharma, 2002). By-products of sugar-cane processing are ideal substrates for breeding of earthworms (Pramanik *et al*., 2007, Manna *et al*., 2003) and give a product rich in chelating and phytohormonal elements with high microbial content and stabilized humic substances (Atiyeh *et al.,* 2001).

Vermicomposting is comparatively new method in composting, and involves the stabilization of organic solid waste through earthworm consumption that converts the waste into earthworm castings. Like the conventional compost, vermicomposting is advantageous to agricultural soil due to increased moisture retention ability, better nutrient holding capacity, superior soil structure, and higher levels of microbial activity (Suthar, 2009). According to Ghosh et al., 1999), vermicomposting might be an efficient technology for providing better P nutrition from different organic wastes. Vermicomposting is being considered as a potential option in the hierarchy of integrated solid waste management. Vermicomposting involves stabilization of organic material by the joint action of earthworms and microorganisms. Although microbes are responsible for biochemical degradation of organic matter, earthworms are the important drivers of the process by conditioning the substrate and altering the biological activity (Aira *et al*., 2007).

The *Eudrillus eugiea* (African Nightcrawlers) is an excellent vermicomposting worm and for almost two decades, the worm have been revitalizing the soil and playing a major role in solid waste management in Southeast Asian (Kale, 1998). This worm species can break down cellulose material without as much help from soil bacteria and when they eat, they leave behind worm castings that can be used as organic fertilizer (Senapathi, 1988; Kale *et al*., 1982).

There are many research reports on vermicomposting of other organic substrates like coffee ground (Adi and Noor, 2008), kitchen waste (Fauziah *et al*., 2009), vegetable waste (Garg and Gupta, 2010) and tomato fruit waste (Manuel *et al*., 2010). This paper reports on the vermicomposting of sugar cane bagasse and leaves using *Eudrillus euginea* as a sustainable approach to produce waste to value added product. This study is aimed to test the practicability of vermicomposting of sugarcane leaves and bagasse using *Eudrilus eugeniae* (African nightcrawler).

2.0 EXPERIMENTAL DESIGN

2.1 Vermibed preparation & Introduction of worms

Containers that measured 50cm x 15cm x 25cm were filled with 1kg mixture of the desired waste and soil at three different ratios (Table 1& 2) to serve as test experiment. Ten worms with the average size of 5.5±0.1cm were introduced into each of the twelve containers while the other twelve containers without worms in corresponding ratios served as control.

Table 1
Description of vermibeds used for experimentations of bagasse ([a] (weight: weight)).

Vermibed	Ratio[a]	Description
A	9:1	90% of sugar cane bagasse and 10% soil
AC	9:1	90% of sugar cane bagasse and 10% soil
B	7:3	70% of sugar cane bagasse and 30% soil
BC	7:3	70% of sugar cane bagasse and 30% soil
C	1:1	50% of sugar cane bagasse and 50% soil
CC	1:1	50% of sugar cane bagasse and 50% soil

Ratio[a] (Waste: Soil)

Table 2
Description of vermibeds used for experimentations of leaves ([a] (weight: weight)).

Vermibed	Ratio[a]	Description
D	9:1	90% of sugar cane leaves and 10% soil
DC	9:1	90% of sugar cane leaves and 10% soil
E	7:3	70% of sugar cane leaves and 30% soil
EC	7:3	70% of sugar cane leaves and 30% soil
F	1:1	50% of sugar cane leaves and 50% soil
FC	1:1	50% of sugar cane leaves and 50% soil

Ratio[a] (Waste: Soil)

2.3 Vermiculture analysis

The samples were analyzed for the following physico-chemical (Table 3&4);

Physical analysis: Colour changes, pH, temperature

a) Chemical analysis: Carbon to Nitrogen ratio, total organic carbon and Nutrient content (Total N, Total P and Total K)

3.0 RESULT & DISCUSSION

3.1 Physico-chemical observations during vermicomposting

Eudrillus eugeniae converted the mixtures into more stabilized odour-free and nutrient-rich material; vermicompost. The textural appearance of the waste mixture changed gradually with the formation worm castings while the control remains the same. The combination of 50 % waste and 50% soil via vermicomposting was the fastest to completely degrade 11 days for sugar cane leaves and 14 days for sugar cane bagasse meanwhile the control took 15 days and 18 days respectively. This is probably due to the presence of more soil to support the activity of the worms. The 70% waste and 30% soil took 14 days to completely degrade leaves and 18 days for sugar cane bagasse whereas the control took 18 days and 22 days, respectively. Finally, the 90% waste and 10% soil required 22 days and 28 days for leaves and sugar cane bagasse to achieve complete degradation while the control took 27 and 38 days, respectively.

The average degradation rate via vermicomposting is 7.14×10^{-2} kg per day for the sugar cane bagasse and 9.09×10^{-2} kg per day for leaves which produced nutrient-rich compost namely 1.01% of P, 0.47% K for sugar cane leaves and this result depicts significant degradation of the waste components by the worms. The overall weight of waste mixture was drastically reduced towards the end of vermicomposting due to active degradation process. Figure 1 indicates the duration for complete vermicomposting of both wastes at different treatment.

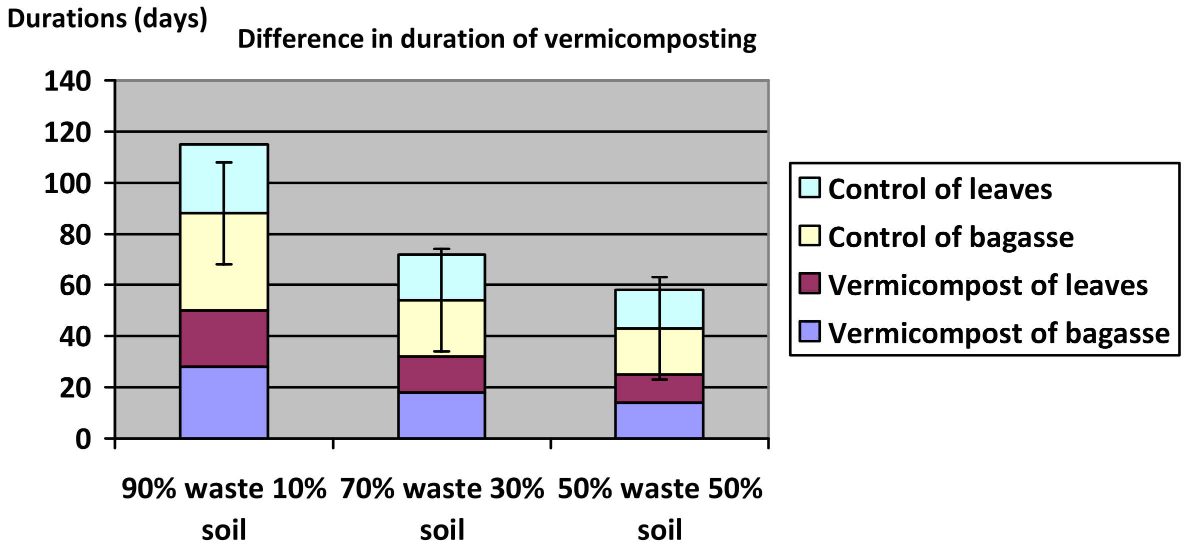

Fig.1.The duration for degradation of spent tea via vermicomposting

3.2 Survival of worms

The waste mixtures in 1:1 ratio were completely degraded after 2 weeks. However the number of worms began to decrease after the first week. This is due to the poor water retaining capacity of the waste. The waste prepared in 9:1 treatment took 4 weeks to degrade completely. However, the number of worms began to decrease after week 3. This is due to diminishing nutrient from waste which has been completely degraded. The number of worms at final weeks differed with different treatment. The abundant cellulose compound in sugar cane bagasse provide nutrient slowly but at a longer period (Miller, 1999).Thus, more worms survived after the 4th week in sugar cane bagasse. Sugarcane leaves cannot retain much water compared to sugarcane bagasse due to the lignified surface area (Doube *et al.*, 1998). Leaves mainly act as respiratory system for a plant so it's not much suitable for vermicomposting. Sugarcane bagasse is a dry material to begin with, then after water been added to the mixture, the bagasse able to absorb an amount of water and retain it gradually. Figure 2 shows the number of worms survived throughout the vermicomposting process for both wastes.

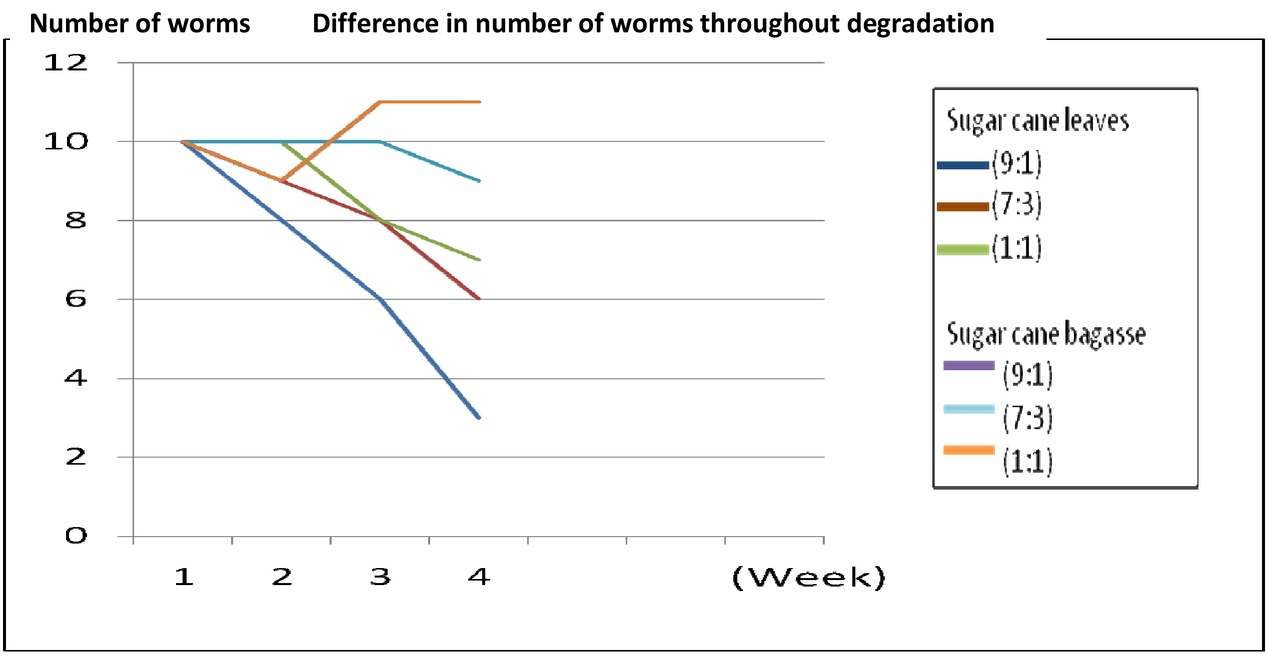

Fig.2. The difference in number of worms throughout the vermicomposting

3.3 Chemical analysis

Chemical analyses of the sugar-cane waste both bagasse and leaves with different treatments showed an increase in detectable phosphorus and potassium possibly because of mineralization of organic matter (Table 2, 3, 4 & 5). The C to N ratio decreased from 58.25 to 14.37 for sugar cane bagasse (Table 2 and Table 3) and 54.28 to 10.54 for sugar cane leaves (Table 4 and Table 5). This indicates that the degradation is faster with the presence of worms since the worms utilized the organic C as the raw materials in their metabolisms that total C content reduced drastically as compared to that of control. The overall results obtained for C/N ratio indicates that both bagasse and leaves has the higher possibility to serve as fertilizer. All the vermicompost treatments have lower organic carbon content in day final compared to the initial and the control setup is because the influence of respiration by microorganism and worms throughout the degradation process (Suthar and Singh, 2008). Available P in vermicomposting treatment increased from 2.47 mg/kg at day zero to 2.67 mg/kg for sugar cane bagasse while from 2.27 to 2.54 for sugar cane leaves. This is due to reaction by the earthworm that may have affected the phosphorus mineralization in wastes. This result agrees with the previous studies that the vermicomposting process enriches the end product with more available forms of plant nutrient (Suthar, 2008c). The mineralization of nitrogen and phosphorus into nitrites/nitrates and orthophosphate and bioconversion of the organic material into intermediate species of organic acids are the cause of the decreasing of pH values in the treatments (Ngedwa and Thompson, 2000).

Table 2
Physico-chemical characteristics of day zero vermicompost for sugar cane bagasse

Parameters	A	AC	B	BC	C	CC
pH	3.16± 0.1	3.18± 0.1	3.14± 0.2	3.16 ± 0.1	2.13 ± 0.3	2.15± 0.2
Total Organic C (%)	14.0± 0.1	13.8± 0.2	9.2 ± 0.2	9.7 ± 0.8	4.3 ± 0.5	4.97± 0.5
Available P(mg/kg)	1.36± 0.05	1.21± 0.03	1.69± 0.2	1.72± 0.1	2.47± 0.01	2.30± 0.02
Exchangeable K(mg/kg)	5.06± 0.07	4.96± 0.06	5.48± 0.1	5.31± 0.2	7.54± 0.2	5.22± 0.1
C :N ratio	58.12± 0.3	57.69± 0.5	57.55± 0.1	58.38± 0.2	58.25± 0.1	57.85± 0.5
Conductivity (µs)	256 ± 2.5	248 ± 2.2	133 ± 0.8	129 ± 0.5	87 ± 0.4	76 ± 0.2

Table 3
Physico-chemical characteristics of final vermicompost of sugar cane bagasse

Parameters	A	AC	B	BC	C	CC
pH	4.68± 0.1	4.70± 0.1	4.66± 0.2	4.61 ± 0.1	5.66 ± 0.4	5.59 ± 0.3
Organic C (%)	6.35± 0.5	9.9 ± 0.7	5.20± 0.2	4.1 ± 0.8	1.71± 0.1	5.27± 0.3
Available P (mg/kg)	1.97± 0.1	1.85± 0.2	2.18± 0.1	2.48± 0.3	2.67± 0.3	2.54± 0.06
Exchangeable K(mg/kg)	5.46± 0.3	5.12± 0.5	6.08± 0.3	6.29± 0.06	8.32± 0.04	7.92± 0.3
C:N ratio	21.17± 0.1	50.69± 0.2	18.41± 0.2	51.93± 0.3	14.37± 0.2	49.95± 0.1
Conductivity (µs)	140± 5.2	189± 5.1	191± 3.2	166± 4.3	226± 3.7	137± 5.9

Table 4
Physico-chemical characteristics of day zero vermicompost for sugar cane leaves

Parameters	D	DC	E	EC	F	FC
pH	5.43± 0.1	5.48± 0.1	5.52± 0.2	5.57± 0.1	6.25± 0.3	6.18± 0.2
Total Organic C (%)	3.85± 0.1	3.45± 0.2	13.33± 0.2	16.85± 0.8	16.9± 0.5	13.35± 0.5
Available P(mg/kg)	0.83± 0.01	1.45± 0.03	1.72± 0.2	1.55± 0.01	2.35± 0.1	2.27± 0.02
Exchangeable K(mg/kg)	0.55± 0.02	0.67± 0.06	1.48± 0.1	1.1± 0.2	1.54± 0.2	2.22± 0.1
C :N ratio	51.37± 0.3	53.28± 0.3	48.96± 0.1	50.73± 0.2	54.28± 0.1	49.11± 0.5
Conductivity (µs)	174 ± 2.4	124± 1.2	164 ± 3.1	180± 3.5	259 ± 2.4	396 ± 4.2

Table 5
Physico-chemical characteristics of final vermicompost of sugar cane leaves

Parameters	D	DC	E	EC	F	FC
pH	6.32 ± 0.1	6.45 ± 0.1	6.50± 0.2	6.66 ± 0.3	6.71± 0.4	6.92± 0.3
Organic C (%)	1.75± 0.2	1.20± 0.1	7.21± 0.2	8.84 ± 0.4	7.32± 0.3	8.87± 0.3
Available P (mg/kg)	1.01± 0.1	1.67± 0.2	1.84± 0.1	1.73± 0.07	2.62± 0.3	2.54± 0.06
Exchangeable K(mg/kg)	0.93± 0.3	1.23± 0.5	1.33± 0.3	1.49± 0.06	2.02± 0.04	1.92± 0.3
C:N ratio	13.08± 0.1	47.23± 0.2	12.58± 0.2	43.47± 0.3	10.54± 0.2	39.73± 0.1
Conductivity (µs)	250± 5.2	104± 5.1	163± 3.2	144± 4.3	143± 3.7	225± 5.9

CONCLUSION

The sugarcane leaves and bagasse can be degraded via vermicomposting using *Eudrilus eugeniae.* However it will eventually reduces the number of surviving worms due to the diminishing source of nutrient. Even though the 1:1 ratio was the fastest ratio to degrade for both waste but looking into the economic point of view, the 70% of waste 30% soil ratio should be implemented for commercial scale waste management. Thus, the potential to convert sugar cane bagasse and sugar cane leaves into compost via vermicomposting is high that further research can be developed for continuous improvement.

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