

**WASTE AUDIT AT COCONUT-BASED INDUSTRY AND
VERMICOMPOSTING OF DIFFERENT TYPES
OF COCONUT WASTE**

TWANA ABDULRAZAQ TAHIR

**FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
KUALA LUMPUR
2012**

**WASTE AUDIT AT COCONUT-BASED INDUSTRY AND
VERMICOMPOSTING OF DIFFERENT TYPES OF
COCONUT WASTE**

TWANA ABDULRAZAQ TAHIR

**DISSERTATION SUBMITTED IN FULFILLMENT OF
THE REQUIREMENT FOR THE DEGREE OF MASTER OF
TECHNOLOGY (ENVIRONMENTAL MANAGEMENT)**

**INSTITUTE OF BIOLOGICAL SCIENCES
FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
KUALA LUMPUR
2012**

UNIVERSITI MALAYA
ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: **TWANA ABDULRAZAQ TAHIR** (I.C/Passport No: **S2746126**)

Registration/Matric No: **SGH080019**

Name of Degree: **Master of Technology (Environmental Management)**

Title of Project Paper/Research Report/Dissertation/Thesis (“this Work”):

WASTE AUDIT AT COCONUT-BASED INDUSTRY AND VERMICOMPOSTING OF DIFFERENT TYPES OF COCONUT WASTE

Field of Study: **WASTE MANAGEMENT**

I do solemnly and sincerely declare that:

- (1) I am the sole author/writer of this Work;
- (2) This Work is original;
- (3) Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;
- (4) I do not have any actual knowledge nor do I ought reasonably to know that the making of this work constitutes an infringement of any copyright work;
- (5) I hereby assign all and every rights in the copyright to this Work to the University of Malaya (“UM”), who henceforth shall be owner of the copyright in this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;
- (6) I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate’s Signature

Date

Subscribed and solemnly declared before,

Witness’s Signature

Date

Name:

Designation:

ABSTRACT

While the increase in the number of agro-based industries in Malaysia supports economic growth positively, it affects environment negatively by generating large amount of agrowaste. This study aimed to identify and quantify the types of coconut waste generated from selected coconut-based industry and tried to assess the possibility of vermicomposting different types of coconut waste. Therefore, this study evaluated the potential of using *Eudrilus eugeniae* to decompose coconut wastes. Also, waste audit was carried out at Kapar Coconut Industry Sdn. Bhd., where different types of coconut-based products were being processed namely, spray dried coconut milk powder and low fat desiccated coconut. The waste audit focused on selected sites; the paring station, production site, packing site, storage, and administration site. Two main types of wastes were often generated throughout the coconut processing, namely coconut husk (CH) from dehusking process (540kg/week) and coconut shell (CS) from deshelling process (1456kg/week). Since, these two types of coconut wastes are considered as organic waste, bioconversion was suggested to be one of the best alternatives for managing these wastes in a manner that potentially avoid or minimize environmental degradation. Vermicomposting process was conducted for three different types of coconut wastes; coconut husk (CH), spent coconut flake (SCF) and coconut shell. The experiments were prepared with three different ratios (100% waste), Goat manure (GM): waste (30:70) and GM: waste (50:50). The physical and chemical analyses were determined at various stages of vermicomposting process for all three types of coconut wastes. The degradation rate was higher in spent coconut flake than with coconut husk and coconut shell. Spent coconut flake needed only 16 days to be completely degraded, the coconut husk required 50 days for total degradation, while coconut shell decomposition continued

even after 50 days. Weight loss at final stage of vermicomposting process was higher in coconut husk than with spent coconut flake and coconut shell. The final concentrations of heavy metals were lower than US biosolid and EU limit standards in all three types of coconut wastes. The C-to-N ratio declined at final stage of vermicomposting process in all three types of coconut waste and it was within favourable ranges (lower than 20) except the coconut shell. The earthworm's (*Eudrilus eugeniae*) weight increased in all three types of coconut wastes, but the number of worms decreased at final stage of vermicomposting. Therefore, this study concluded that all three types of coconut wastes could be decomposed at different rates and also inferred that this worm (*Eudrilus eugeniae*) is a potential bioagent for faster degradation of coconut waste. Moreover, from the economic point of view, the coconut-based industry could gain more profit from vermicomposting coconut wastes instead of selling the waste out.

ABSTRAK

Peningkatan jumlah industri asas tani semakin meluas di Malaysia sekaligus membantu pertumbuhan yang positif dari segi ekonomi. Namun demikian, ia memberi impak negatif terhadap alam sekitar disebabkan oleh pertambahan jumlah sisa pertanian yang turut meningkat. Kajian ini bertujuan untuk mengenal pasti dan mendapatkan kuantiti jenis-jenis sisa kelapa yang dihasilkan daripada industri terpilih berasaskan kelapa di samping untuk menilai kebarangkalian kajian vermipengkomposan dengan menggunakan jenis-jenis sisa kelapa yang berbeza. Justeru, kajian ini juga bertujuan untuk menilai potensi penggunaan cacing *Eudrilus eugeniae* dalam penguraian sisa kelapa. Selain daripada itu, audit sisa juga telah dijalankan di Kapar Coconut Industri Sdn. Bhd, di mana pelbagai jenis produk berasaskan kelapa diproses di industri tersebut iaitu, serbuk santan kelapa dan kelapa kering rendah lemak. Audit sisa difokuskan kepada bahagian yang terpilih iaitu, tapak pengupasan, tapak pengeluaran, bahagian pembungkusan, penyimpanan, dan pentadbiran. Terdapat dua jenis sisa utama yang terhasil di sepanjang pemprosesan kelapa iaitu, sabut kelapa daripada proses peleraian sabut (540kg/minggu) dan tempurung kelapa daripada proses pengupasan kelapa (1456kg/minggu). Kedua-dua jenis sisa kelapa tersebut dianggap sebagai sisa organik, maka penukaran biologi telah dicadangkan untuk menjadi salah satu alternatif yang terbaik dalam menguruskan sisa ini dan berpotensi untuk mengelakkan atau mengurangkan pencemaran alam sekitar. Proses vermipengkomposan telah dijalankan ke atas tiga jenis sisa kelapa iaitu; sabut kelapa, hampas kelapa dan tempurung kelapa. Sebanyak tiga jenis nisbah yang berbeza dijalankan dalam kajian ini iaitu, nisbah (100% sisa), nisbah tahi kambing:sisa (30:70) dan nisbah tahi kambing:sisa (50:50). Analisis kimia dan fizikal telah ditentukan mengikut setiap peringkat proses

vermipengkomposan yang berbeza daripada ketiga-tiga jenis sisa kelapa tersebut. Kadar degradasi adalah lebih tinggi pada hampas kelapa berbanding dengan sabut kelapa dan tempurung kelapa. Hampas kelapa hanya mengambil masa selama 16 hari untuk didegradasi sepenuhnya, manakala sabut kelapa memerlukan 50 hari untuk didegradasi dan tempurung kelapa mengambil masa lebih daripada 50 hari untuk proses degradasi yang lengkap. Penurunan berat cacing pada peringkat akhir proses vermipengkomposan mencatatkan jumlah yang lebih tinggi pada sabut kelapa berbanding hampas kelapa dan tempurung kelapa. Kepekatan logam berat adalah lebih rendah daripada AS biosolid dan had piawai EU pada ketiga-tiga jenis sisa kelapa semasa di peringkat akhir kajian. Nisbah C kepada N adalah berkurang pada peringkat akhir proses vermipengkomposan untuk ketiga-tiga jenis sisa kelapa dan ia adalah dalam julat yang memuaskan (lebih rendah daripada 20) kecuali tempurung kelapa. Berat (*Eudrilus eugeniae*) cacing tanah meningkat dalam ketiga-tiga jenis sisa kelapa, namun bilangan cacing menurun pada peringkat akhir vermipengkomposan. Berdasarkan kajian, dapat disimpulkan bahawa ketiga-tiga jenis sisa kelapa boleh diuraikan pada kadar yang berbeza dan cacing (*Eudrilus eugeniae*) adalah merupakan agen biologi yang berpotensi untuk mendegradasikan sisa kelapa dengan segera. Selain itu, dari sudut ekonomi, pihak industri berasaskan kelapa seharusnya tidak menjual sisa kelapa begitu sahaja, sebaliknya lebih banyak keuntungan dapat diperolehi dengan melakukan proses vermipengkomposan sisa kelapa.

ACKNOWLEDGMENT

To God who gave me the ability to complete my project successfully. I would like to acknowledge the advice and guidance of Dr. Fauziah Shahul Hamid, who supervised me all through carrying out this research. Here, I should extend my most sincere and deepest gratitude to her for providing me with infinite support, continual encouragement and insight. It is due time to express my thanks to the respectable faculty members and staff of the Faculty of Science and Institute of Science Biology at the University of Malaya. I also thank Emenice Chijioke, Mohammed Javanmiri, Omar almuktar Ali, Zhila, Afifa and Shamini for their valuable advises. Special thanks also go to the management and staff of Kapar Coconut Industry Sdn. Bhd., without their guidance and assistance, this study would not have been successful.

I acknowledge the IPPP for their financial support for this project. My thanks, moreover, goes to the UM library staff for providing the necessary resources needed to carry out my research.

Last but not the least, I sincerely dedicate this work to my beloved family and especially to my dear parents and my siblings whose prayers, appreciation and encouragement have always kept my spirits high at every single moment of my life. Had it not been for their support and encouragement, I would not have finished my Masters.

TABLE OF CONTENTS

Abstract	ii
Abstrak	iv
Acknowledgements	vi
Table of contents	vii
List of Figures	ix
List of Tables	x
List of plates	xi
List of abbreviations	xii

CHAPTER 1 INTRODUCTION

1.1	Waste Composition in Malaysia	14
1.2	Overview on Agro-Industrial Waste	15
1.2.1	Coconut Industry in Malaysia	16
1.2.2	Kapar Coconut Industries (KC) Sdn. Bhd.	17
1.3	Waste Management Options in Coconut-Based Industry	18
1.4	Problem Statement	19
1.5	Objectives of Project	19

CHAPTER 2 LITERATURE REVIEW

2.1	Solid Waste Generation- Global Scenario	20
2.2	Solid Waste Generation- Malaysian Scenario	21
2.3	Waste Management Options	24
2.3.1	General View of Waste Management Options	24
2.3.2	Waste Minimization Program	25
2.4	Agro-Based Industry	28
2.4.1	Agro-Based Industry Definition	28
2.4.2	Coconut -Based Industry –Global Scenario	29
2.4.3	Coconut Products	32
2.4.4	Coconut – Based Industry- Malaysia Scenario	34
2.5	Waste Audit	39
2.6	Bioconversion	42
2.6.1	Vermicomposting	43
2.6.2	Anatomy of Earthworms	44
2.6.3	Chemical Parameters and Microorganisms in Vermicomposting	50

CHAPTER 3 WASTE AUDIT

3.1	Introduction	58
3.2	Waste Audit Procedure	59
3.2.1	Specification of Audit Scope	59
3.2.2	Collection of General Background Information	59
3.2.3	Determination and Quantification of the Generated Waste	60
3.2.4	Managing and Analyzing the Data for Waste Audit Report	60

3.3	Waste Audit Result	60
3.3.1	Audit Scope	61
3.3.2	Collection of General Background Information	62
3.3.3	Determination and Quantification of the Generated Waste	75
3.3.4	Quantification of Generated Waste at the Selected Sites	
CHAPTER 4 VERMICOMPOSTING		
4.1	Introduction	78
4.2	Methodology	79
4.2.1	Materials and Experimental Design	79
4.2.2	Physical and Chemical Analyses	83
4.3	Results and Discussion	85
4.4	A Comparison Between Different Types of Coconut Wastes	124
4.5	Conclusion	125
CHAPTER 5 GENERAL DISCUSSION		
5.1	Introduction	126
5.2	Economic Aspect of Vermicomposting	129
CHAPTER 6 CONCLUSION		
		132
REFERENCES		
		133

LIST OF FIGURES

Figure 2.1: Hierarchy of Waste Management	25
Figure 2.2: Various Advantages of Waste Minimization Program	26
Figure 2.3: World Important Producers of Coconut in 1996	30
Figure 2.4: Desiccated Coconut (DC) Process Flow Diagram	33
Figure 3.1: Waste Generated Inside Paring Station	63
Figure 3.2: Waste Generation From Process Operation (Production Site)	64
Figure 3.3: Waste Generation From Process Operation of Coconut Milk Powder	66
Figure 3.4: Waste Generation From Process Operation of Desiccated Coconut	68
Figure 3.5: Waste Generation From Process Operation of Shredded Coconut	69
Figure 3.6: Waste Generation From Packaging Process	70
Figure 4.1: Layering System of Vermicomposting Experimental Set-up for C2-W	79
Figure 4.3: Degradation Rates of the Set-ups with and without Worms	87
Figure 4.4: Comparative of Experimental Set-up and Control (without Worm)	88
Figure 4.5: Weight Loss of the CH at the Final Stage	89
Figure 4.6: Weight Loss of the SCF at the Final Stage	89
Figure 4.7: Weight Loss of the CS at the Final Stage	90
Figure 4.8: Weight Loss of Coconut Wastes at the Final Stage	91
Figure 4.9: Differences Between Weight Loss in the Experiments	92
Figure 4.10: EC Value of Vermicomposting Process of CH	95
Figure 4.11: EC Value of Vermicomposting Process of SCF	96
Figure 4.12: EC Value of Vermicomposting Process of CS	96
Figure 4.13: Salinity Value during Vermicomposting Process of CH	98
Figure 4.14: Salinity Value during Vermicomposting Process of SCF	99
Figure 4.15: Salinity Value during Vermicomposting Process of CS	99
Figure 4.16: The pH Values during Vermicomposting Process of CH	101
Figure 4.17: The pH Values during Vermicomposting Process of SCF	102
Figure 4.18: The pH Values during Vermicomposting Process of CS	102
Figure 4.19: Value of Phosphorus during of Vermicomposting of CH	109
Figure 4.20: Value of Phosphorus during of Vermicomposting of SCF	109
Figure 4.21: Value of Phosphorus during of Vermicomposting of CS	110
Figure 4.22: The Value of Total Potassium during Vermicomposting of CH	112
Figure 4.23: The Value of Total Potassium during Vermicomposting of SCF	112
Figure 4.24: The Value of Total Potassium during Vermicomposting of CS	113

LIST OF TABLES

Table 2.1: World Growing Area of Coconut 1992-1996 (Unit: 1000 Hectares).	31
Table 2.2: Production of Agricultural Commodities, 2000-2010	37
Table 2.3: Agricultural Land Use, 2000-2010	38
Table 3.1: Available Background Information from the Company	61
Table 3.2: Waste Generation from Human Resource Management Section	72
Table 3.3: Waste Generation from Production Manager Section	73
Table 3.4: Waste Generation from Marketing Section	73
Table 3.5: Waste Generation from General Manager Section	74
Table 3.6: Waste Generated Weekly by the Selected Locations	76
Table 3.7: Summary of the Waste Generated at Various Site in the Company	77
Table 4.1: Combination of Vermicomposting Set-ups with CH	80
Table 4.2: Combination of Vermicomposting Set-ups with SCF	81
Table 4.3: Combination of Vermicomposting Set-ups with CS	82
Table 4.4: Metals and Macronutrient Concentrations in CH	105
Table 4.5: Metals and Macronutrient Concentrations in SCF	106
Table 4.6: Metals and Macronutrient Concentrations in CS	107
Table 4.7: The Value of Total Organic Carbon during Vermicomposting of CH	114
Table 4.8: The Value of Total Organic Carbon during Vermicomposting SCF	115
Table 4.9: The Value of Total Organic Carbon during Vermicomposting of CH	115
Table 4.10: The Value of TN during Vermicomposting of CH	117
Table 4.11: The Value of TN during Vermicomposting of SCF	117
Table 4.12: The Value of TN during Vermicomposting of CS	118
Table 4.13: C-to-N Ratio during Vermicompostin of CH	119
Table 4.14: C-to-N Ratio during Vermicompostin of SCF	120
Table 4.15: C-to-N Ratio during Vermicompostin of CS	120
Table 4.16: Multiplication of Earthworms (Weights and Numbers) of CH	122
Table 4.17: Multiplication of Earthworms (Weights and Numbers) of SCF	123
Table 4.18: Multiplication of Earthworms (Weights and Numbers) of CS	123
Table 5.1: Approximate Cost of the Components for Vermicomposting of Coconut Waste	129
Table 5.2: Approximate Cost for Vermicomposting Process of 350g of Coconut Waste	130
Table 5.3: Summary of the Cost and Profit from Vermicomposting 1 tonne of Coconut Waste	130

LIST OF PLATES

Plate 1: Chopped Coconut Husk (CH) during the Initial Stage When <i>Eudrilus eugeniae</i> was Introduced	80
Plate 2: Spent Coconut Flakes (SCF) at the Initial Stage of Vermicomposting Process	81
Plate 3: Coconut Shell (CS) at Initial Stage of Vermicomposting Process	82
Plate 4: The Colour of C2-W Totally Shifted to Brown at Final Stage	93
Plate 5: The Colour of SCF Completely Changed to Brown at Final Stage	93
Plate 6: The Colour of CS Changed at Final Stage	94

LIST OF ABBREVIATIONS

Kg	Kilogramme
IPCC	Intergovernmental Panel on Climate Change
Cm	Centimeter
Cap	Capita
CH	Coconut husk
SCF	Spent coconut flake
CS	Coconut shell
m	Meter
MYR	Malaysian Ringgit
KC	Kapar coconut industry
GHG	Greenhouse gases
EU	European Union
MSW	Municipal solid waste
VCO	Virgin Coconut Oil
DC	Desiccated coconut
UNEP	United Nation Environmental Programme
UNIDO	United Nation Industry Development Organization
EC	Electrical conductivity
VS	Volatile solids
WTP	Wastewater treatment plant
CMP	Coconut Milk Powder
SC	Shredded Coconut
GM	Goat manure