ABSTRAK

Pengeluaran kertas serata secara global adalah 4%. Walaubagaimanapun, di lokasi dinamic seperti China, pengeluaran kertas melebihi 8% pada dekad yang lalu. Jumlah pengeluaran kapasiti oleh kilang kertas Malaysia telah mencapai 1.3 juta ton/tahun manakala pengambilan kertas melebihi pengeluaran kapasiti. Di Kuala Lumpur, ibu kota Malaysia, kertas adalah komponent kedua besar dalam Municipal Solid Waste (MSW). Sektor kertas dan "pulp" merupakan salah satu konsumer sumber "kayu serat" yang terbesar, yang meninggalkan kesan terhadap iklim dengan mempengaruhi sumber perhutanan.

Universiti Malaya (UM), sebagai sebuah insititut akedemik, yang mempunyai lebih daripada 27,000 pelajar dan 1,700 staf akedemik dengan 17 buah pusat kajian, telah dipilih untuk melaksanakan kajian sisa kertas. Objektif kajian ini adalah: (1) untuk mengendali dan mengukur pengeluaran sisa kertas di UM (Kolej kediaman, fakulti, pusat kajian, institute dan pejabat pentadbiran) dan (2) untuk mengenalpasti pengurusan sisa-sisa kertas di UM. Metodologi yang digunakan untuk kajian ini adalah melalui pemerhatian, koleksi data, perkunjungan dan wawancara.

Selepas kajian, Kolej Kediaman Keduabelas mencatatkan pengeluaran sisa kertas terbanyak, iaitu 683.4 kg/bulan manakala Kolej Kediaman Pertama mengeluarkan sisa kertas yang kedua terbanyak, iaitu 480 kg/bulan. Selain itu, Koleh Kediaman Ketujuh menunjukkan statistics yang paling rendah dalam pengeluaran sisa kertas, iaitu 73 kg/bulan. Daripada fakulti berdasarkan program praktikal, Fakulti Kejuruteraan menghasilkan 33.9 kg kertas putih (yang paling banyak) manakala Pusat Sukan menghasilkan 3.6 kg. Selain daripada itu, daripada fakulti yang tidak mempunyai praktikal, Faculty of Built Environment menghasilkan 48.7kg kertas putih manakala Institut Asia Eropah menghasilkan 5kg kertas putih yang mencatatkan rekod

yang terendah. Keputusan daripada kajian menunjukkan pengeluaran kertas putih sebanyak 41.6kg daripada Bangunan Canselor manakala Muzium Seni Asia mencatatkan 7.9kg. Pusat Pentadbiran dan Bahagian Kewangan, dan Jabatan Pendaftaran merupakan pembekal sumber kertas kepada semua Kolej Kediaman dan pejabat pentadbiran manakala sesetengah fakulti mendapatkan sumber kertas mereka daripada pembelian di luar UM. Jabatan ini pada tahun 2008 telah membeli 50,000 rim kertas dan jumlah ini meningkat sebanyak 40% pada tahun 2009 kepada 70,000 rim kertas.

ABSTRACT

The average global paper production growth was 4% annually. However, in some dynamic region such as China, this amount exceeded 8% in the last decade. Total production capacity of Malaysian paper mill reached 1.3 million tonnes/year while the consumption of paper is more than the production capacity. In Kuala Lumpur, the capital city of Malaysia, the second most abundant component of Municipal Solid Waste (MSW) is paper. Paper and pulp sector are one of the main consumers of fibrous wood resources which, has significant impact on the climate change by effecting forest resources.

University of Malaya as an academic institute with more than 27,000 students and 1,700 academic staff with 17 faculties and research centers was chosen for the study on waste paper. The objectives of this study are: to identify and quantify of waste paper generation in UM (Residential Colleges, Faculties, Research Center, Institute and Administration offices) and to identify of waste paper management in University of Malaya. The methodology used for this research is from observation, data collection, site visit and interview.

It was found that, Twelfth College generated 683.4 kg/ month of white paper which is the highest among the other residential colleges and First College is in the second by 480 kg/month. Seventh College generated the lowest amount by 73 kg/month. From the faculties based on practical courses, Faculty of Engineering generated33.9 kg of white paper which is highest and sport center generated 3.6 kg. On the other hand, from the Faculties with no practical Faculty of Built Environment generated the amount of 48.7 kg of white paper and Asian Europe Institute with 5 kg is the lowest one. Results shown that Chancellery Building generated 41.6 kg of white paper while Art Asia Museum was the lowest with 7.9 kg. Administration and Finance

Division, Registration Department is supplied paper for all Residential Colleges and Administration offices while some faculties purchased their paper from outside the UM. This department in 2008, purchased 50,000 reams of paper and in 2009 it was increased by 40% to 70,000 reams of paper.

ACKNOWLEDGEMENTS

The author wishes to sincerely thank the following people:

I am heartily thankful to my supervisor, Professor Dr. Agamuthu, whose encouragement, guidance and support from the initial to the final level enabled me to develop an understanding of the subject.

I would also thanks to Mr. Musavi from Pars Paper Factory for his kindly cooperation during the data collection.

Finally, the author wishes to acknowledge her family, for their patience, inspiration and total support. A special thank you must go to my husband, my children and my parents for their continue support and care shown during my study. This work is dedicated to them.

The last not the least I offer my regards and blessings to all of those who supported me in any respect during the completion of the project.

POOPAK SOTOODEHNIA 2011

TABLE OF CONTENTS

ABSTRAK……i

ABSTRACT……ii

ACKNOWLEDGEMENTS v

LIST OF FIGURES iix

LIST OF TABLES xi

LIST OF ABBREVIATIONS AND DEFINITION xii

CHAPTER ONE 1

1. INTRODUCTION 1

1.1. Solid Waste 1

1.2. Paper Production / Consumption Scenario in Malaysia 4

1.3. Limitations and Problems related to Recycling in Malaysia 8

1.4. Problem Statement 8

1.5. Objectives of Research 8

CHAPTER TWO 10

2. LITERATURE REVIEW 10

2.1 Solid Waste 10

2.2 Sources of Solid Waste 13

2.3 Solid Waste Management 13

2.3.1 Elements of a Waste Management System 14

2.4 Solid Waste Management in Malaysia 17

2.5 Paper Production / Consumption 18

2.6 Waste Minimization 22

2.6.1 Waste Minimization Concept 23

2.6.2 Benefits of Waste Minimization 29

2.6.3 Waste Minimization in Malaysia 29
2.7 Clean Technology 30
2.7.1 Benefits of Cleaner Technology 31
2.7.2 Cleaner Technology in Malaysia 32
2.8 Recycling 33
2.8.1 Benefits of Recycling 34
2.8.2 Recycling in Malaysia 34
2.9 Life Cycle Assessment (LCA) 36
2.9.1 Definition of LCA 37
2.9.2 LCA Methodology 40

CHAPTER THREE 43

3. MATERIALS & METHODOLOGY 43
3.1. Waste Paper Management in the University of Malaya (UM) 43
3.1.1. Waste Paper Generation 44

CHAPTER FOUR 48

4.1. Introduction 48
4.2. Waste paper generation in Residential Colleges 49
4.2.1. The First Residential College 54
4.2.2. The Second Residential College (Tuanku Bahiyah Residential College) 54
4.2.3. The Third Residential College (Tuanku Kurshiah Residential College) 55
4.2.4. The Fourth Residential College (Bestari Residential College) 55
4.2.5. The Fifth Residential College (Daya Sari Residential College) 55
4.2.6. The Sixth Residential College (Ibnu Sina Residential College) 56
4.2.7. The Seventh Residential College (Za'ba Residential College) 56

4.2.8. The Eight Residential College (Kinabalu Residential College) 56

4.2.9. The Tenth Residential College (Tun Ahmad Zaidi Residential College)..... 57

4.2.10. The Eleventh Residential College (Ungku Aziz Residential College) 57

4.2.11. The Twelfth Residential College (Raja Dr Nazrin Shah Residential College) ……58

4.3. Waste paper generation in Faculties 60

4.3.1. Waste paper generation based on Practical Courses in Faculties 62

4.3.2. Waste Paper generation in faculties (no practical) 64

4.4. Waste Paper generation in other places in UM..... 67

4.5. Waste paper generation in Chancellery Building 71

4.6 A Case Study of Life Cycle Assessment (LCA) on Paper production process in Iran..... 74

4.6.1 Introduction..... 74

4.6.2 LCIA Analysis 86

4.6.3 Results and Discussion 89

4.6.4 General Conclusion..... 101

4.7 Summary..... 104

CHAPTER FIVE..... 108

5 CONCLUSION AND RECOMMENDATIONS 108

5.1 Conclusion 108

5.2 Recommendation 109

5.2.1 Enforce the regulation on paper recycling programme in UM. 109

5.2.2 Training and teaching of cleaners and staff..... 110

5.2.3 Techniques..... 110

5.2.4 Using recycle paper instead of using virgin paper..... 111

REFERENCES..... 112

LIST OF FIGURES

Figure 1.1: Types and Percentage of MSW in developed countries 2

Figure 1.2: Composition of MSW in Malaysia 4

Figure 1.3: Pulp and paper production in the world by regions and by grade (2004) 5

Figure 1.4: MSW Recyclables in Kuala Lumpur 6

Figure 2.1: Relationship between waste and value 12

Figure 2.2: Pulp and paper production in the world by regions and by grade (2004), total 360 million tonnes 21

Figure 2.3: Waste Management hierarchy (Source: Baghchi, 2004) 24

Figure 2.4: Various benefits accrued from implementation of Waste Minimization Program Source: (Clark, 1995) 28

Figure 2.5: A Full Life Cycle Assessment Process , (Source: Sumiani, 2009) 38

Figure 2.6: Life Cycle Assessment (Environment Management in the Value Chain) (Source: Sumiani, 2009) 39

Figure 2.7: Framework of Life Cycle Assessment under ISO 14040 41

Figure 3.1: Location of University of Malaya (UM) 44

Figure 3.2: UM Map 74

Figure 4.1: White paper generation in Residential Colleges during the period of one month 81

Figure 4.2: Paper production process 75

Figure 4.3: Transported the Bagasse through the conveyer belts from the sugarcane factory to the paper factory 76

Figure 4.4: Cooking process on pulp mill in paper factory 77

Figure 4.5: Pulp Screening and Cleaning in Pars Paper Factory……...77

Figure 4.6: Cooking process on pulp mill in paper factory 78

Figure 4.7: Pulp Screening and Cleaning in the paper factory 79

Figure 4.8: Paper Mill Process 80

Figure 4.9: Wet End (Formation) section 81

Figure 4.10: Wet End (Press Section) section 82

Figure 4.11: Drying Section..... 83

Figure 4.12: Callevdering Section 83

Figure 4.13: Life cycle of paper and system boundary of this study (dotted line) 86

Figure 4.14: Impact of paper production process from all inputs for producing of one metric tonne of paper for one year. 90

Figure 4.15: Input values in percentage for global warming impact for producing of one metric tonne of paper for one year. 92

Figure 4.16: Input values in percentage for abiotic depletion for producing of one metric tonne of paper for one year. 94

Figure 4.17: Inputs for Acidification impact 95

Figure 4.18: Inputs for Eutrophication impact..... 96

Figure 4.19: Inputs for Ozone layer depletion impact 97

Figure 4.20: Inputs for photochemical oxidation impact..... 99

Figure 4.21: Inputs for human, freshwater, marine and terrestrial ecotoxicity impacts 100

Figure 4.22: Life Cycle of copy paper 103

Figure 4.23: Comparison of waste paper generation in one week 103

LIST OF TABLES

Table 1.1: Organic and inorganic components of MSW in selected countries..... 3

Table 2.1: Comparison between production of paper and board in 2005 and 2006 in different regions:..... 19

Table 2.2: Total Paper Consumption in 2006 (collection + import - export) for the different regions (in million tonnes):..... 20

Table 2.3: Total Collection of paper in 2005 and 2006 and total Consumption in 2006 in Malaysia (million tonnes)..... 21

Table 2.4: Priority Issues in National Waste Management 36

Table 4.1: White paper generation in Residential Colleges (kg/month)..... 51

Table 4.2: Waste paper generation in Faculties based on practical Courses 92

Table 4.3: Waste Paper generation in Faculties (non- practical) for one week..... 95

Table 4.4: waste paper generation in other places in UM 97

Table 4.5: Summary of no of reams that supplied by UM for Chancellery Building offices and no of staff 72

Table 4.6: Impact Categories and Units..... 88

Table 4.7: Input from paper production process..... 89

Table 4.8: Comparison of paper purchased between KU and UM..... 106

LIST OF ABBREVIATIONS AND DEFINITION

A.E.I : Asia Europe Institute

AIS : Academy of Islamic Studies

APM : Academy of Malay Studies

BC : Before Christ

C : Cardboard

C_2H_2 : Acetylene

CED : Cumulative Energy Demand

CFC-11 : Trichlorofluoromethane

CFSS : Center of Foundation for Studies in Science

CO_2 : Carbon dioxide

CP : Cleaner Production

CT : Cleaner Technology

DANCED : Danish Cooperation for Environment and Development

1,4- DB : 1,4 – Dichloro Benzene

DCA : Dewan Chancellor Administration

DOE : Department Of Environment

DQI : Data Quality Indicator

EASEWASTE : Environmental Assessment of Solid Waste Systems and Technology

EDIP : Environmental Design of Industrial Product in Danish

EDIP : Environment Design of Industrial Product in Danish

EDP : Environmental Product Declaration

EIA : Environmental Impact Assessment

EPS : Environmental Priority Strategies in Product design

EPSM : Environmental Protection Society Malaysia

FMM : Federation Malaysia Manufactures

GaBi : Pc-tool selected by Danish LCA center

GVC : Gross Colorific Value

IPS : Institute of Postgraduate Studies

ISO : International Standards Organization

ISWM : Integrated Solid Waste Management

JPPHB UM : Department of Development & Asset Maintenance University of Malaya

Kg : Kilogram

KL : Kuala Lumpur

LCA : Life Cycle Assessment

LCI : Life Cycle Inventory

LCIA : Life Cycle Impact Assessment

LIME : Life cycle assessment Method based on Endpoint modeling

M : Mixed paper

M^3 : Cubic Meter

MICCI : Malaysian International Chamber of Commerce and Industry

MSW : Municipal Solid Waste

MSWM : Municipal Solid Waste Management

NGO : Non- Government Organization

OBA : Optical Brightness Agency

PO_4--- : Phosphate ion

RM : Ringgit Malaysia

Sb : Antimony

SEMC : Swedish Environment Management Council

SETAC : Society of Environmental Toxicology And Chemistry

Simapro : System for Integrated Environmental Assessment of Product

SIRIM : Standards and Industrial Research Institute of Malaysia

SMI : Small and Medium scale Industrial

SO_2 : Sulfur dioxide

UM : University of Malaya

UNEP : United Nations Environmental Program

USEPA : United States Environmental Protection Agency