



UNIVERSITI PUTRA MALAYSIA

**DEVELOPMENT OF AN INDUSTRIAL TOXIC AND HAZARDOUS
WASTE
MANAGEMENT MODEL BASED ON END-OF-PIPE AND INDUSTRIAL
ECOLOGY APPROACHES**

AHMAD FARIZ MOHAMED

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**DEVELOPMENT OF AN INDUSTRIAL TOXIC AND HAZARDOUS WASTE
MANAGEMENT MODEL BASED ON END-OF-PIPE AND INDUSTRIAL
ECOLOGY APPROACHES**

By

AHMAD FARIZ MOHAMED

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

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LIST OF ABBREVIATIONS

3R	Reuse, Reduce and Recycle
AHP	Analytical hierarchy process
DfE	Design for Environment
DOE	Department of Environment Malaysia
DOSH	Department of Safety and Health Malaysia
DSD	Duales System Deutschland
EC	European Commission
EMS	Environmental Management System
EOP	End-of-Pipe Approach
EPA	Environmental Protection Agency Taiwan
EQA	Environmental Quality Act 1974, Malaysia
ESM	Environmentally Sound Management
EU	European Union
GDP	Gross Domestic Product
GPS	Global Positioning System
IE	Industrial Ecology
IMP	Industrial Master Plan Malaysia
IMP2	Industrial Master Plan 2 Malaysia
ISO	International Standard Organization
IWCC	Industrial Waste Control Centre Taiwan
KA	Kualiti Alam Sdn Bhd
LDR	Land Disposal Restriction Program
LIFT	Legislation, Institutional, Financial and Technology



MIC	Methyl isocyanate
MIDA	Malaysian Industrial Development Authority
MOEA	Ministry of Economic Affairs Taiwan
MOSTE	Ministry of Science, Technology and Environment Thailand
MSW	Municipal Solid Waste
NRE	Ministry of Natural Resources and Environment Malaysia
OECD	Organisation of Economic Co-operation and Development
PCB	Polychlorinated biphenyl
RCRA	Resource Conservation and Recovery Act 1976, United States
RM	Ringgit Malaysia
SIRIM	Standards and Industrial Research Institute of Malaysia
SMIDEC	Small and Medium Industry Development Corporation
SWDA	Solid Waste Disposal Act 1965, United States
SWOT	Strength, Weakness, Opportunities and Threat
UNEP	United Nations Environment Programme
US	United States
USA	United States of America
USEPA	United States Environmental Protection Agency
WCED	World Commission on Environment and Development

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PEMBENTUKAN MODEL PENGURUSAN SISA TOKSIK DAN BERBAHAYA
INDUSTRI BERASASKAN PENDEKATAN “END-OF-PIPE” DAN EKOLOGI
INDUSTRI**

Oleh

AHMAD FARIZ MOHAMED

Ogos 2007

Pengerusi: Professor Muhammad Awang, PhD.

Fakulti: Pengajian Alam Sekitar

Kajian tesis ini menilai sistem pengurusan sisa toksik dan berbahaya industri di Malaysia. Kajian juga merangkumi analisa tren penghasilan sisa, pembangunan industri dan pengambilan semula sisa. Penilaian dan analisis dasar dan pengurusan menjurus kepada empat sektor iaitu perundangan, institusi, kewangan dan teknologi (LIFT). Hasil penilaian dan analisis dan juga maklumat lain yang dikumpul telah digunakan untuk menentukan isu-isu dan lompong dalam pengurusan sisa. Bahagian seterusnya kajian tesis ini membangunkan sistem pengurusan yang lebih baik melalui model ex-ante ekologi industri untuk pengurusan sisa toksik dan berbahaya di Malaysia, yang menggunakan konsep dan pendekatan ekosistem dalam konteks sudut pandangan pembangunan lestari.

Analisa tren yang dilakukan termasuk analisa penghasilan sisa, pengembalian sisa, pembangunan industri dan pengeluaran industri. Industri Malaysia menghasilkan 4.1 juta metric ton sisa toksik dan berbahaya dari tahun 1994 hingga 2003, dengan purata

418,230 metrik ton setahun. Hasil analisa menunjukkan tren pertumbuhan industri pembuatan untuk indeks pengeluaran dan sumbangan KDNK menunjukkan hubungan korelasi positif dengan penghasilan sisa sebelum tahun 1996 dan selepas 1997. Pengurusan sisa di Malaysia boleh dikategorikan kepada tiga aktiviti iaitu, rawatan dan pelupusan, eksport and pengembalian semula sisa. Analisa agihan telah menunjukkan ia menyokong pengurusan menggunakan pendekatan ekosistem. Ini adalah kerana peningkatan jumlah pengembalian semula sisa toksik dan berbahaya melalui pelaksanaan inisiatif kitar semula sisa dan keberkesana guna sumber. Jumlah pengembalian semula sisa meningkat dua kali ganda, dari 120,570 metric pada tahun 2000 kepada 250,260 metrik ton pada tahun 2003. Dalam peratus, pengembalian semula sisa menyumbang 34.99 % pada tahun 2000 dan 54.30 % pada tahun 2003, dengan jumlah anggaran nilai RM 2.83 bilion untuk tempoh dari tahun 2000 hingga 2003.

Penyiasatan dan analisa juga telah dilakukan untuk menentukan kebolegunaan pendekatan ekosistem untuk pengurusan sisa toksik dan berbahaya di Malaysia. Analisa dasar dan pengurusan telah dilakukan untuk memeriksa kepentingan factor-faktor yang merujuk kepada sektor LIFT. Faktor-faktor yang telah dikenalpasti digunakan sebagai komponen utama untuk membangunkan model ex-ante Ekologi Industri untuk pengurusan sisa toksik dan berbahaya yang baik. Model ini dibangunkan dengan mempunyai ekosistem sendiri dan merangkumi empat habitat. Setiap habitat mempunyai peranan, fungsi dan memberi perkhidmatan. Rangkaian yang wujud antara habitat mempertingkatkan keberkesanan ekosistem. Model ex-ante ini memfokus kepada pengurusan aliran sisa toksik dan berbahaya sebagai sumber dan mensasarkan peningkatan kitaran sisa kepada sumber serta mengurangkan kitaran sumber sebagai

sisa. Intipati model ini ia mempromosikan peranan pro-aktif industri dan perniagaan serta membantu mempertingkatkan imej alam sekitar mereka. Sehubungan itu juga meningkatkan keyakinan pelanggan terhadap produk dan meningkatkan jualan. Secara keseluruhan kajian tesis ini jelas menunjukkan bahawa pendekatan ekosistem amat berguna. Antara laba yang penting adalah pengurangan pelupusan sisa ke persekitaran, pengurangan kebergantungan kepada sumber asli seperti tanah untuk pelupusan sisa serta peningkatan keberkesanan aktiviti permonitoran dan penguatkuasaan. Akhirnya kesemua laba ini juga menguntungkan kerajaan dan masyarakat untuk mencapai pembangunan industri lestari di Malaysia.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

**DEVELOPMENT OF AN INDUSTRIAL TOXIC AND HAZARDOUS WASTE
MANAGEMENT MODEL BASED ON END-OF-PIPE AND INDUSTRIAL
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By

AHMAD FARIZ MOHAMED

August 2007

Chairman: Professor Muhammad Awang, PhD.

Faculty: Environmental Studies

This study attempts to evaluate the existing industrial toxic and hazardous wastes management systems in Malaysia and subsequently proposed a new model for enhancing the efficiency and sustainability of the system. This includes analyzing the trends in waste generation, industrial development, industrial production and waste recovery. Evaluation and analysis of policy and management were focused on four main sectors, namely, legislation, institutional, financial and technology (LIFT). Findings of evaluation and analysis as well as other information gathered were used to determine issues and gaps in managing wastes. Subsequently the study developed a model for a better management system based on ex-ante Industrial Ecology model for industrial toxic and hazardous waste management in Malaysia using ecosystem concept and approach within the sustainable industrial development perspective.

Trend analysis has been conducted which includes the analysis of waste generation, waste recovery, industrial development and industrial output. Malaysian industry



generated 4.1 million metric tons of toxic and hazardous wastes from 1994 to 2003, with an average of 418,230 metric tons per year. It appeared that the growth trend of manufacturing in terms of production index and GDP contribution had a positive correlation with waste generation prior to 1996 and after 1997. The management of wastes in Malaysia could be categorized into three activities namely, treatment and disposal, export to foreign countries, and waste recovery. The analysis of waste distribution supported the suggestion for the ecosystem approach management. This is due to the fact that increasing amounts of toxic and hazardous waste has been recovered following the adoption of waste recycling and resource efficiency initiatives. The amount of waste being recovered has doubled from 120,570 metric tons in 2000 to 250,260 metric tons in year 2003. In terms of percentage of waste recovery represented 34.99% for 2000 and 54.30% for 2003, respectively of total wastes generated with estimated value of RM 2.83 billion.

Further investigation and analysis has been performed to determine the applicability of ecosystem approach for toxic and hazardous management in Malaysia. Policy and management analyses were conducted to examine the importance of the factors based on LIFT sectors. These identified factors were adopted as the main components towards the development of an ex-ante Industrial Ecology model for a better toxic and hazardous waste management in Malaysia. The model was created as an ecosystem encompassing four habitats. Each of these habitats has its own role, function and service as well as the networks between the habitats improves the ecosystem efficiency. Essentially the ex-ante model ecosystem focused on managing the flow of waste as a resource with the main target being to increase the cycle of waste to resources and to reduce the flow of resources to waste. In essence it promotes more pro-active roles by industry and business

and helps to enhance their environmental image thus increasing consumer confidence in their products and therefore sales. The overall finding of the present study clearly indicates that ecosystem approach proved to be useful. The benefits include minimization of waste disposals to the environment, reduction of dependency on natural resources such as land use for disposal sites and enhancement of efficient monitoring and enforcement activity. Finally all these benefits would lead to increased benefits to government and the society in terms of achieving sustainable industrial development in Malaysia.

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I certify that an Examination Committee has met on 13th June 2007 to conduct the final examination of Ahmad Fariz Bin Hj Mohamed on his degree thesis entitled “Development of An Industrial Toxic and Hazardous Waste Management Model Based On End of Pipe and Industrial Ecology Approaches” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Mohamed Ibrahim Hj. Mohamed, PhD.

Professor, Capt.
Department of Environmental Management
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

Mohd Ismail Yaziz, PhD.

Associate Professor
Department of Environmental Science
Faculty of Environmental Studies
Universiti Putra Malaysia
(Internal Examiner)

Puziah Abdul Latiff, PhD.

Department of Environmental Science
Faculty of Environmental Studies
Universiti Putra Malaysia
(Internal Examiner)

Raymond Coté, PhD.

Professor
School of Resource and Environmental Studies
Faculty of Management
Dalhousie University
Canada
(External Examiner)

HASANAH MOHD GHAZALI, PhD.

Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 16 August 2007



This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

Muhammad Awang, PhD.

Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

Mohd Nasir Hassan, PhD.

Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Member)

Dato' Abu Bakar Jaafar, PhD.

Enviro-LIFT Sdn Bhd
(Member)

AINI IDERIS, PhD.

Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 13 September 2007



DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

AHMAD FARIZ BIN HJ MOHAMED

Date: 15 August 2007

CHAPTER 1

INTRODUCTION

1.1 Introduction

Industrial toxic and hazardous wastes are two of the key environmental pollutants. The absence of an effective management regime for these wastes has created many issues and opportunities. The impact and implication of these wastes go beyond the common production line of industries to the consumption of products. Illegal dumping and accidents involving toxic and hazardous wastes negatively affect humans and the environment, the impact of which will last many years (Carson, 1962, Bellandi, 1995 and Colten and Skinner, 1996). One of the world's well known examples was the case of Love Canal in Niagara Falls, USA where the impact of illegal dumping of hazardous wastes created negative incidents to human and the environment from 1954 to 1977 (Colten and Skinner, 1996). The costs of remediation of the dumping have come to over USD 250 million. These incidents lead to President Carter to issue two environmental emergencies for the Love Canal area in 1978 and 1980, resulting in the evacuation of 950 families from a 10 square block area surrounding the landfill (USEPA, 2004).

Therefore it is important to have a secured and efficient toxic and hazardous wastes management system. This system will ensure that the handling of these wastes would minimize its impact on humans and the environment. Rapid technological development enables these wastes to be handled and treated safely albeit increasing amount of toxic and hazardous wastes are generated. But the question remains, how long do we have to



manage these wastes using this end-of-pipe approach? Since the costs incurred in managing the waste keep increasing, a sustainable solution needs to be identified. The solution must ensure that toxic and hazardous wastes generation would not give negative impact on humans and the environment as well as to achieve sustainable industrial development in Malaysia.

1.2 Statement of Problem

Malaysia, as one of the fastest developing countries in the Asia region has, for the last three decades, been experiencing rapid development. One of the key sectors contributing to Malaysia's economic growth is the manufacturing industry. For thirty years, the manufacturing sector has become Malaysia's key economic generator. The rapid growth of manufacturing industries increased income and quality of life. Industrial developments in Malaysia started in the early 1960s and in 1996 contributed RM 45.2 billion to the growth domestic product (GDP). Although during the economic recession from 1997 to 1998 manufacturing growth reduced to 13.4% of GDP contribution, the growth has bounced back to 13.5% in 1999 and 21% in 2000. This growth has contributed to 33.4% of Malaysia GDP in 2000 (Malaysia, 2001). The Manufacturing industry will continue as a key sector in the economy of Malaysia with target growth of 8.9% per annum from 2001 to 2005 which will contribute 35.8% to the GDP by 2005 (Malaysia, 2001). The positive impact of industrial growth in Malaysia however does have negative implications for the environment. One of the issues is the need to manage industrial toxic and hazardous waste effectively which has been one of the key environmental issues in Malaysia.

Toxic and hazardous waste generation varied where 417,413 metric tons of waste was generated in 1994. The amount of wastes generated then increased to 632,521 metric tons in 1996, however reduced to 460,865.74 metric tons in 2003 (DoE, 1995, 2000, 2004). Thus the existing management system needs to address measures in handling increasing and complex industrial toxic and hazardous waste issues. Based on the manufacturing production and consumption of resources scenario, industrial toxic and hazardous waste management in Malaysia has been focusing on end-of-pipe approach. Using the cradle to grave system, much of the waste was sent to facilities for treatment and disposal (Lindgren, 1989). Moreover, with the industrial community's attitude regarding waste as waste, some of them do not bother to manage their waste with care (Taiwan EPA, 2004). This promotes increasing generation of waste annually with only small amount being recovered, since the waste is currently regarded as a non-valuable resource. Furthermore the costs of handling and disposal of toxic and hazardous waste will increase industries operating costs which make managing waste a burden. Therefore, some industries illegally disposed the waste into lakes, rivers, seas and plantations or export to other countries illegally. Many cases of illegal disposals have taken place and have given significant negative impacts to the environment and human health (Third World Network. 1989, Goh, 1990, The Star, 2003a, The Star, 2003b). This is true, since a significant number of compounds have been issued by DoE under Environmental Quality (Scheduled Wastes) Regulation of 1989 for illegal dumping of toxic and hazardous wastes activities. The number of compounds issued have increased from 193 in 1994 to 599 in 1998 and then the number of compounds reduced to 450 in 2003 (DoE, 1995, 2000, 2004).