UNIVERSITI PUTRA MALAYSIA

LIFE CYCLE ASSESSMENT FOR MANAGING HOUSEHOLD WASTE IN TEHRAN, IRAN

HELEN MORABI HERAVI

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

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HELEN MORABI HERAVI

March 2014

Chair: Professor Mohd Bakri Ishak, PhD
Faculty: Environmental studies

Life cycle assessment (LCA) methodology in this thesis was used to determine the optimum Recyclable Household Waste management strategy for Tehran city. The thesis targets the household waste of Tehran, and the problem was made by posing significant environmental, health hazards, and harming economies. The municipality intends to eliminate activities that have the potential to cause a non-compliance till prevent recurrence. Corrective actions have an effect on the potential problems which is a crucial issue for any major cities worldwide. Tehran is a large urban cluster, which is chosen for this study. The study also fits with the five year waste management, design of the municipality. Life cycle management (LCM) of household waste is analyzed based on direct data observations. The current research has relevance in solving real life environmental problems.

The main aim of the study was examined and recommends ways to reduce the environmental emissions of recyclable household waste operations. The goal of study to assess the environmental potential effects such, acidification; global warming , eutrophication, solid waste and water consumption per capita of household waste in the steps of storing, collecting and recycling by IMPACT2000+ Method. Type study is cradle to cradle of the LCA method.

The main objective of this thesis is studying the achievement to optimum potential environmental impacts per 200 kg capita in managing household waste. The specific objectives are the identification of the most environmentally aspects (EMS), to assess the risk of the unit processes of household waste, to analyze the inventory of unit processes, to determine the correlation between inputs and out-puts also determine the sensitivity value outputs to inputs in the life cycle, to assess potential environmental emissions and environmental impacts of three group scenario in the life cycle and, to determine of the best scenario for Tehran. The objectives focus on related sustainable development and environment issues and the current status of different environmental tools.

Database emissions were estimated by the World Health Organization (WHO) and Japan International Cooperation Agency (JICA). Life Cycle Assessment (LCI)

provides the basis for evaluating the potential environmental impacts. The thesis adopts a unique combination of analytical and field based methods. The key component is direct observations and field data collections, which is strengthened by different analysis and models. An analysis is made based on observed data and models. Both direct and indirect emissions associated with source separation practices as well as those avoided due to replacing storage bag/bin and vehicles. The categories of environmental and resource consumption that is proportional to the local and global level, mainly includes the effects of acidification, global warming, respiratory effect, solid waste and water consumption.

System boundary recyclable materials are as cradle to cradle and the separation and storage of recyclable materials has been started from homes, kerbside or buy back centers and ultimately lead to recycling factories. Functional unit is calculated based on the capita of collecting recyclable materials. Collection and storage of various types of recyclable materials used different equipment. Due to time and resource constraints, this LCA evaluates the potential impacts storage bags and vehicle collection in the recyclable household waste, a 57% door-to-door service, 34% kerbside sorting, and 9% buyback centers by work sheets.

An effective source separation management system is needed in Tehran since the generated recyclable materials are separated in the kerbside without any control and hasn't had a materials recovery facility (MRF)/Transfer Stations (TS). Waste (MSW) produced in Tehran was 7,000 metric tons per day. Currently, Tehran produces more than 2.5 million tonnes of waste every year. Waste analysis was carried out in all of the 22 Tehran regions, the results shows that 32% of waste is recyclable. Waste source separation promotes the use of reachable waste and reduce environmental and health risks as well as the national capital.

Several waste source separation schemes were implemented in Tehran regions, including: Tehran waste management organization currently promote and support initiative waste source separation programs of the buyback center, door-to-door service and kerbside sorting. Most local authorities have practiced forms of reclamation in past years. Source separation schemes were established in 1995 by contractors that currently covenant its surplus to participating local and government contractors in developing their long-term strategy.

These containers are located in various places around the main city of the region – Tehran. There are 22 regions where people can bring their pre-separated recyclable materials. The collected materials, in principle, are going to be sold to recycling companies and then to the market.

In this thesis source separation alternative were investigating an environmental impact and process risk. Waste source separation is concluded that there is a high risk of recycling due to lack of quality control of the product. The thesis concludes with a series of actions for municipal waste management. With detailed literature review, original data analysis, and has been able to provide in-depth analysis of the research problem and has provided recommendations. The alternative scenarios were compared through the IMPACT 2000+Method (Excel file of Gabi software; ver 2.1) and these comparisons were carried out from the global warming, human respiratory, acidification, eutrophication, water consumption, and solid waste points of view.

In total, nine different scenarios were developed as alternatives on management system of the recyclable household and hotspot analysis is made considering its environmental impacts. Impacts on respiration, BOD, Total N, acidification, global warming is calculated based on these nine scenarios. Storage, collection of recyclable materials and recycling processes were considered in these scenarios. According to the comparisons, sensitive analysis and emission burden model, in all nine scenarios, total emissions are consistently lower when plastic bag is used rather than paper bags.

To perform each of the suggested scenarios will depend on the decision policies. It is recommended developing a kerbside with High Density Polystyrene (HDPE) blue bins and exciting buy back centers programs in the near future. A kerbside system by HDPE blue bin by using mini-truck is the more environmentally preferable alternative and process has lower risk. Recommendation, used on mini-truck and kerbside collection are the most commonly used source separation systems, that are perform in worldwide.

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

PENILAIAN KITARAN HAYAT BAGI MENGURUSKAN SISA ISI RUMAH DI TEHRAN-IRAN

Oleh

HELEN MORABI HERAVI

Mac 2014

Pengerusi:Professor Madya Mohd Bakri Ishak, PhD
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Kaedah Penilaian Kitar Hayat (LCA) dalam penyelidikan ini telah digunakan untuk menentukan secara optimum strategi pengurusan kitar semula sisa isi rumah di Bandar Tehran. Tesis ini tertumpu kepada sisa isi rumah dan juga masalah yang timbul daripada tindakan penjagaan alam sekitar, risiko kesihatan dan ancaman ekonomi. Majlis perbandaran lebih memilih untuk menolak aktiviti yang berpotensi meyebabkan ketidakpatuhan sehingga sampai ke tahap mengelakkan daripada pengulangan kembali. Tindakan pembetulan member kesan kepada masalah-masalah yng berpotensi iaitu menjadi isu penting kepada mana-mana ibu kota secara global.

Tehran adalah kelompok bandar besar sebagaimana dipilih untuk penyelidikan ini. Penyelidikan ini juga berpadanan dengan corak pengurusan sisa selama lima tahun oleh majlis perbandaran. Pengurusan kitar hayat adalah system pengurusan sisa isi rumah yang dianalisa berdasarkan data pemerhatian secara terus. Penyelidikan terkini menunjukkan kesesuaian dalam penyelesaian masalah alam sekitar yang nyata.

Tujuan utama penyelidikan ini adalah untuk menyelidik dan mencadangkan cara untuk mengurangkan pelepasan kepada alam sekitar melalui pengoperasian sisa isi rumah yang bole dikitar semula. Sasaran penyelidikan ini adalah untuk menilai kesan alam sekitar yang berpotensi seperti pengasidan; pemanasan global dan eutrophicasion, kaedah penyimpanan sisa pepejal dan penggunaan air per kawasan sisa isi rumah, pengumpulan serta kitar semula melalui kaedah *IMPACT2000+*. Jenis penyelidikan ini berasal dari kaedah LCA.

Objektif utama tesis in adalah untuk menyelidik pencapaian kepada potensi kesan-kesan alam sekitar yang optimum per 200 kg kapasiti dalam pengurusan sisa isi rumah. Objektif-objektif khusus adalah menentukan aspek paling mesra alam (EMS), menyelidik risiko setiap unit pemprosesan sisa isi rumah, menganalisa senarai unit pemprosesan, menentukan hubungan antara kemasukan dan pengeluaran serta nilai kepekaan pengeluaran kepada kemasukan dalam kitar hayat, menilai potensi pelepasan kepada alam sekitar dan kesan alam sekitar terhadap tiga kumpulan scenario dalam kitaran hayat dan mementukan scenario terbaik bagi Tehran.

Pangkalan data pelepasan telah dianggarkan oleh Pertubuhan Kesihatan Sedunia (WHO) dan Agensi Kerjasama Jepun dan Antarbangsa (JICA). Penyenaraian kitar hayat (LCI) menyediakan tapak untuk penilaian kepada kesan-kesan alam sekitar yang berpotensi. Tesis in mengadaptasi gabungan unik analisis dan kaedah lapangan. Komponen kekunci adalah pemerhation secara terus dan pengumpulan data lapangan dimana kekuatannya terletak kepada perbezaan analisis dan model. Analisa dilakukan berdasarkan data pemerhatian dan juga model. Kedua-dua pelepasan sama ada secara langsung atau tidak langsung digabungkan dengan tindakan pengasingan daripada sumber dan pengelakkan tindakan tersebut disebabkan penukaran penyimpanan beg/tong serta kenderaan. Kategori alam sekitar dan penggunaan sumber yang berkadar terus dengan tahap tempatan dan global termasuk kesan pengasidan, pemanasan global, kesan pernafasan, sisa pepejal dan penggunaan air.

Sistem kesempadanan kitar semula barangan adalah berasal dari pengasingan dan penyimpanan baerangan kitar semula telah bermula dari rumah, di kaki lima atau di pusat penebusan dan khususnya diterajui oleh kilang-kilang kitar semula. Unit kefungsian dikira berdasarkan kapasiti pengumpulan barangan kitar semula. Pengumpulan dan penyimpanan pelbagai jenis barangan kitar semula menggunakan peralatan berbeza. Disebabkan kekangan masa dan sumber, LCA ini menilai kesan potensi penyimpanan beg dan kenderaan pangumpulan sisa isi rumah yang dikitar semula iaitu 57% dari perkhidmatan pintu ke pintu, 34% dari kutipan di kaki lima dan 9% dari pembelian di pusat penebusan.

Sistem pengurusan pengasiangan sumber yang berkesan diperlukan di Tehran disebabkan barangan kitar semula yang terhasil kini diasingkan di kaki lima tanpa pemantauan dan ketiadaan kemudahan pemerolehan kembali barangan (MRF)/ stesen pemindahan (TS). Di Tehran, secara purata 7,000 tan metric sisa dihasilkan setiap hari bagi setiap kawasan bandar. Terkini, lebih daripada 2.5 juta tan sisa dihasilkan secara tahunan di Tehran. Berdasarkan analisa sisa yang dilakukan, 32% adalah sisa yang boleh dikitar semula. Promosi pengasingan sumber yang boleh dikitar semula dijangka akan membantu dalam aktiviti kitar semula dan penghindaran pencemaran alam sekitar disamping kehilangan modal Negara.

Pelbagai skim telah dilaksanakan untuk pengumpulan barangan kitar semula oleh organisasi pengurusan sisa di Tehran iaitu di lokasi yang berbeza dan dibahagikan kepada tiga kumpulan; pusat penebusan, perkhidmatan pintu ke pintu dan pengasingan di kaki lima menjadi inisiatif yang digunapakai di Bandar Tehran dalam hal pengasingan sumber. Kebanyakan badan berkuasa tempatan telah mempraktikkan pelbagai bentuk tuntutan selama beberapa tahun yang lepas. Skim pengasingan sumber telah dibangunkan pada tahun 1995 oleh kontraktor-kontraktor swasta dan kerajaan dalam penmbangunan strategi jangka panjang.

Bekas-bekas ini terletak di beberapa lokasi sekitar bandar utama di Tehran. Terdapat 22 kawasan di mana penduduk boleh membawa sendiri barangan kitar semula yang separa terasing. Barangan terkumpul secara prinsipnya akan dijual kepada syarikat-syarikat kitar semula dan seterusnya ke pasaran.

Alternatif pengasingan sumber dalam tesis ini telah dikaji berdasarkan kesan alam sekitar dan risiko pemprosesan. Pengasingan sisa daripada sumber dapat dirumuskan bahawa aktiviti kitar semula ini mempunyai risiko yang tinggi disebabkan kurangnya pengawasan kualiti produk. Rumusan daripada tesis ini adalah siri-siri tindakan untuk pengurusan sisa. Senario-senario alternative dibandingkan melalui Kaedah Impak 2000+ (fail Excel daripada perisian Gabi; versi 2.1) dan perbandingan ini dilakukan berdasarkan pandangan pemanasan global, pernafasan manusia, pengasidan, eutrophication, penggunaan air, dan sisa pepejal.

Secara keseluruhan, sembilan senario berbeza telah dibangunkan sebagai alternative system pengurusan barangan isi rumah yang boleh dikitar semula dan analisa titikpanas dijalankan dengan mengambil kira kesan alam sekitar. Kesan kepada pernafasan, BOD, jumlah N, pengasidan dan pemanasan global dikira berdasarkan 9 senario tersebut. Penyimpanan, pengumpulan barangan yang bole dikitar semuladan dan proses kitar semula turut diambil kira. Berdasarkan perbandingan, analisa kepekaan dan model bebanan pelepasan, jumlah pelepasan adalah rendah secara konsisten pada kesemua sembilan senario apabila beg plastic digunakan jika dibandingkan dengan beg kertas.

Susunan kedudukan kesan alam sekitar daripada alternative yang dipilih bergantung kepada keputusan polisi lain. Dicadangkan alternative pengasingan sumber untuk masa hadapan adalah tong biru Politilen ketumpatan tinggi (HDPE) di kaki lima dan juga pusat penebusan kembali. System tong biru HDPE di kaki lima dengan penggunaan trak mini adalah alternative alam sekitar yang bersesuaian disamping risiko pemprosesan adalah rendah. Dicadangkan agar penggunaan trak mini dan pengumpulan di kaki lima adalah sistem pengasingan sumber yang menjadi aktiviti kebiasaaan di seluruh dunia. Untuk jangka masa yang panjang, secara amnya pengurusan sisa isi rumah yang boleh dikitar semula ini sangat bergantung kepada keputusan politik.

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To my family and best wishes for long life, health and happiness

To my dear father that I'm looking forward to seeing him

Last but not least, I gratefully acknowledge kind support provided by UPM members

This thesis was submitted the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Commitee were as follows:

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LIST OF ABBREVIATIONS

BOD	Biological oxygen demand
CO	Carbon monoxide
COD	Chemical oxygen demand
CO_2	Carbon dioxide
EPA	United States Environmental Protection Agency
ISO	International Standards Organization (International Organization of Standardization)
KWh	Kilowatt-hour
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact assessment
LCM	Life cycle management
MJ	Mega joule
NO_2	Nitrogen dioxide
SETAC	Society of Environmental Toxicology and Chemistry
SO_2	Sulfur dioxide
GWP	Global warming potential
ODP	Ozone depleting Potential
POCP	Photochemical ozone creation potential
AP	Acidification potential

LIST OF SYMBOLS

A'   Negative ideal solution

A* Positive ideal solution

CHAPTER 1

INTRODUCTION

The rubbish that generated as individuals in homes and which local council is obliged to collect and dispose on our behalf was known as household waste (Waite, 1995). Clearly, if collection program is the one-sort, all recyclable collect as a commingled type, that a single container is the most efficient option. Usually, one-sort systems employ kerbside collection. It is theoretically possible to operate a drop-off or a buyback program that accepts all recyclable mixed together (Lund, 2001). The choice between wheeled carts, as used in Tehran or a bag depends on the collection behaviour of people (separate collection or co-collection). The alternative, a series of smaller containers, would have to be stored in the home until collection day, taking up valuable space. Rectangular boxes are preferred over round buckets by both participants and collection crews; in addition to ease of collection, they are less susceptible to being blown away by high winds. They are somewhat more expensive, however. Citizens are major solid waste producers and significant quantities of recyclable materials can be removed by the contractors of governmental. Home storage of the recyclable materials needs to be considered. Apartments typically have small kitchens and limited storage space. Commingled collection is generally advisable under such settings-one storage container takes up less space than three. Residents would then deliver the commingled recyclable materials to the set-out point, where they may be required to sort the materials into appropriate bins or place them in a single large container. Each multifamily situation will present unique challenges.

Creative, flexible approaches to the collection may be more appropriate than a strictly prescriptive approach. Recyclable material collection systems were designed for the residential sector in Tehran, it is critical to understand what can be efficiently recovered from the waste stream of each establishment. Industry typically recycles a large amount of pre-consumer scraps around Tehran. Kerbside separation refers to the process by which the collector receives commingled recyclable and separates them into refuse during the act of putting them into a vehicle. Residential recycling has always been the process that starts at the home. The responsibility for keeping recyclables out of the refuse bin and sorting the materials is with the residents. The efficiency of the mixed refuse processing Tehran's systems is high enough to recover a sufficient quantity of recyclable to meet program goals and mandates at an affordable price. The mixed refuse processing might be a good solution for some cities. This research is only expressed in emissions from the waste of HDPE plastic bins, plastic and paper bags, and focus on the discussion of potential environmental impacts. Emissions are different in different waste management practices.

The aim of sustainable management is more segregated recyclable materials from garbage value through lower energy usage and lower environmental impacts. In general, short-term goals for a recycling program will be oriented toward planning for decrease of the effects of the system. These will include monitoring a recycling plan; determining which storage equipment's will initially be targeted and how the residential sector of the community will be served. Long term goals will usually pertain to the attainment of a mandated or self-imposed reduction impact system management of waste (UNEP/SETAC, 2005). Life cycle assessment is the process of assessing the environmental burdens associated with a product. LCA is assessing the impact of the energy and material uses and releases to the environment. LCA identify and evaluate opportunities to affect environmental improvements (SETAC, 2001). Indefensible activities understand an open loop system as a cradle to grave that will not extend and has one day to come to a conclusion. Sustainable waste management should be changed from the traditional life cycle analysis (cradle-to-grave) scheme to a new (cradle-to-cradle) scheme without a disposal (El-Haggar, 2007). The municipality dose so in the context of increasingly stringent legislation. The development of economic policies and other measures that foster environmental protection, and increased concern expressed by interested parties about environmental matters and sustainable development (ISO, 2006). This thesis assesses the environmental burdens associated with both a storage bag/bin and kinds of vehicle by identifying and quantifying energy and materials used and wastes released into the environment to assess the impact of those, to identify and evaluate opportunities to affect environmental improvements by the life cycle assessment method.

1.1 Problem Statement

The main cause of making the waste management service problems was made by posing significant environmental, health hazards, and harming economies. Tehran municipality, a pioneer in the process of obtaining ISO14001 standardized certification .In supplement, all associations, companies, organizations, and bodies are anticipated to comply with the provisions of these guidelines and principles. As a community of approximately 22 regions, the Tehran municipality experiences a wide-range of challenges related to the significant environmental, source consumption, technical issues, harming economics, and health hazards of its systems. Technical issues and source consumption difficulties often interfere with vehicle types and can adversely affect significant environments. In addition, preventing harming economics will enhance their benefits and lead to more productive, successful programs and decreasing the rate of non-compliance. With respect to the issue, the Tehran municipality identified the environmental aspects of its management system, in 22 regions of Tehran. Identify aspects are considered the inputs and outputs, activities, products and services. In this regards, Tehran municipality have focused on the household waste collection that can prevent environmental impact and human risks. Sorting can cause serious dangers, especially when segregation products from hospital waste are involved. Unfortunately, these items cause serious human injury that including, injuries, property damage and/or environmental damage. The municipality intends to continuously improve the quality of the household waste system through the use of the corrective and preventive actions and management system. The municipality intends to eliminate activities that have the potential to cause a non-compliance till prevent recurrence. Corrective actions have an effect on the potential problems. The municipality shall take action to eliminate the causes of potential non-compliance in order to prevent their occurrence. LCA is a versatile decision-making tool to quantify the overall environment impacts of its service. Figure 1.1 shows the challenges in Tehran household waste.

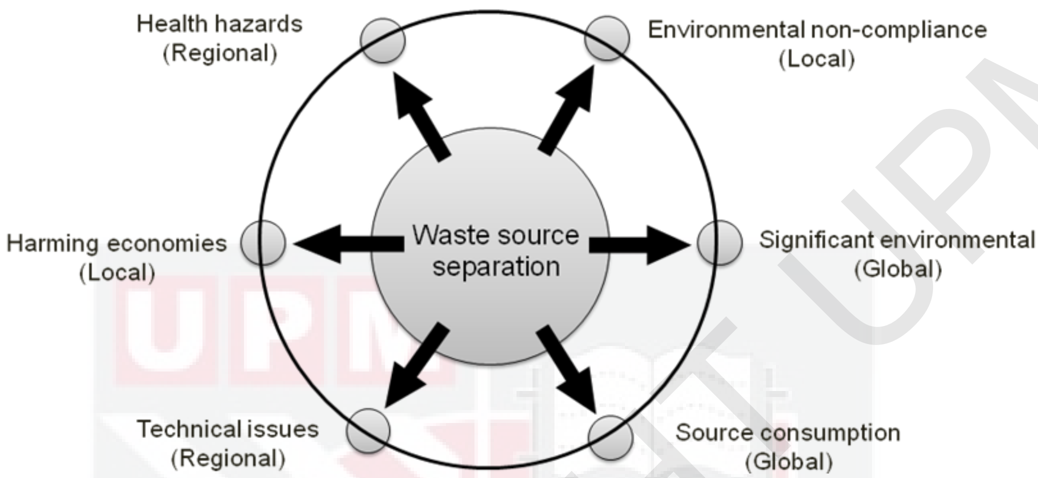

Figure 1.1 Challenges and problems in Tehran household waste

1.2 Significant of The Study

Pickup truck and motor three wheeled vehicles are the backbone of the collection systems of recyclable household waste in Tehran, and therefore they constitute a very important element of the collection system. Tehran's waste management organization in most areas monitored performance of contractors in order to try to make the process more efficient. Assessment of potential the emitted burdens of scenarios for selecting the best scenarios show significant of study. What is needed an innovation to help solve problem to reduce the potential of environmental impacts in scenarios. The reasons for the importance of the study including:

a. Stops the problem of shifting environmental impacts
b. Enables minimizing of secondary effects of a new design service, process or product
c. Enable reducing of environmental pollution and resource use
d. Using environmental management, including LCA, can often improve profitability
e. Can help to understand of true and total monetary and environmental costs of manufacture and design of the product, process or service
f. Demonstrate transparency and corporate credibility to stakeholders and customers.

Strengths of LCA including:

(1) Study the consumption or production of resource in the similar products.
(2) Provide a inventory from same perspective in data source and usage
(3) Improve a product or a input-output by a life cycle assessment
(4) Quantifying of the environmental impacts with a product, process or service in the same perspective
(5) Study of the holistic and comprehensive with a product, process or service
(6) Decision about a product ,process or service with attention to cradle–to-grave a life cycle
(7) Stop of shifting environmental impacts to elsewhere in life cycle.
(8) LCA is time-less, meaning that the time period over which the product is considered is the entire life-span of the product (e.g., from the product's creation to its final disposal).
(9) The problem of how to allocate environmental impacts of multi-functional processes among functions or products is still controversial.

Weakness of LCA including:

(1) Results obtained can be specific and it can be difficult to extrapolate out to all industries
(2) Availability inventory data
(3) The best estimates are required
(4) Data collection is time-consuming and costly
(5) Uncertainties in the estimate of emissions
(6) Uncertainties in life cycle assessment methods

1.3 Research Questions

The collection systems involve municipal waste collection vehicles that emissions burdens generated by them in the environment. The main goal is to provide the best services with the least impact on human health and environmental effects. LCA can help lead to the development of new products, processes, or activities to reduce emissions and resource consumption to solve problems. In this regard, the following issues are stated:

(1) How does the environmental aspects effect on the system management during produce the storage bag/bin or recycling facilities?
(2) How does the risk of processes, effect on the system management during produce the storage bag/bin or recycling facilities?
(3) Is there a relationship between the amounts of inputs and out-puts in the life cycle?
(4) Is there a difference in the optimal levels of the environmental emissions and environmental impacts across the three group scenarios?
(5) Is there a difference in the distance between current scenarios to designed scenario whit attention to the exciting seven criteria? Which scenario is the best?

1.4 Study Objectives

General objective
The main objective of the thesis is to achieve the optimum potential environmental impacts per capita recyclable household waste and risk of the process for managing recyclable household waste.

Specific objective
The purpose of setting specific objectives is to determine what we want to do for achieving the objective of the life cycle. Scope contains all parts that have significance to the environment. Thereby the main points are focused to it are:

(1) To identify and assess the environmental aspects ,input and outputs of the recyclable household waste in the life cycle
(2) To assess the risk of the recyclable household waste system in the life cycle
(3) To analyze the inventory of the unit processes including to determine the correlation between inputs and out-puts and to determine the sensitivity value outputs to inputs in the life cycle
(4) To assess potential environmental emissions and environmental impacts in the three group scenario in the life cycle
(5) To rank of the scenarios for determining the best performance of household waste in the life cycle

1.5 Organization of The Thesis

In chapter one, in order to identify all inputs within the scope of application of LCA, is explained enough concern about any product, service, or process in the proposed comprehensive quality management system. In chapter two, with attention to the scope of this thesis, is explained an LCI was completed for all the activities. For each unit process, and to increase data quality, all data were investigated and all official documents and declarations of similar companies were used to compare ere source consumption and environmental pollution of waste management. In embarking on LCA, there is no absolutely right or wrong approach based on priority. The methodology explained in ISO 14040 is one of the several methods of its expression. In chapter three, with attention to the aim of the thesis that is on the selecting of the best scenario for Tehran household waste, in this application, the research findings were used for decision making. In chapter four, in order to managing of activities relating to organizations with attention to assess potential of environmental impacts of the life cycle of household waste and determine factors affecting the system with the aim of ranking them, was used the following method for the purpose of identification of quantitative factors affecting the assessment of the life cycle in unit processes. Figure 1.2 shown thesis organization. In chapter five, was designed nine scenarios for managing of household waste in Tehran with the aim of ranking them. In chapter six with attention to results of decision making in last chapter purpose the best scenario for managing of household waste Tehran.

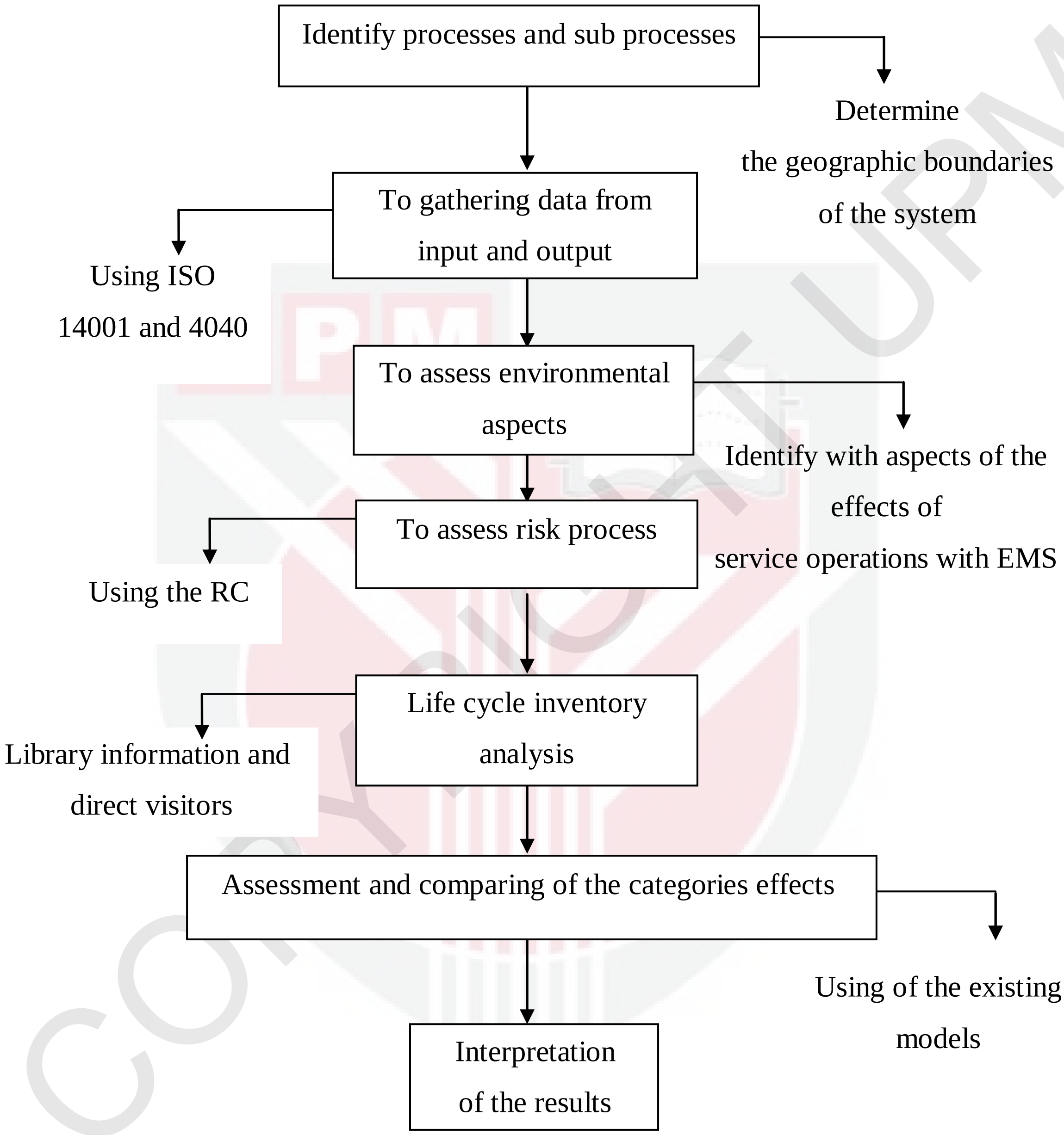

Figure 1.2 Thesis organization

REFERENCES

Ahluwalia, P. K., & Nema, A. K. (2007). A life cycle based multi-objective optimization model for the management of computer waste. *Resources, Conservation and Recycling*, *51*(4), 792–826. doi:10.1016/j.resconrec.2007.01.001

Air Quality Control, C. (1997). *Tehran Transport Emision reduction Project,TERP* (Draft Fina., pp. 1–9). Tehran: Air Quality Control Co.

ARASB. (2010). Kavar608. Retrieved from http://arasbgroup.com/index.php?option=com_content&view=article&id=139

Arena, U., Mastellone, M. ., & Perugini, F. (2003). The environmental performance of alternative solid waste management options: a life cycle assessment study. *Chemical Engineering Journal*, *96*(1-3), 207–222. doi:10.1016/j.cej.2003.08.019

Bahman, M. (1974). Mazda B2000i. Retrieved from http://www.bmcenterco.com/Lists/List21/DispForm.aspx?ID=4

Banar, M., Cokaygil, Z., & Ozkan, A. (2009). Life cycle assessment of solid waste management options for Eskisehir, Turkey. *Waste Management (New York, N.Y.)*, *29*(1), 54–62. doi:10.1016/j.wasman.2007.12.006

Bare, J.C., Norris, G.A., Pennington, D.W., and McKone, T. (2003). “TRACI – The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts.” *Journal of Industrial Ecology*, *6*(3-4), 49–78. Retrieved from http://mitpress.mit.edu/jie

Barlaz, M. A., Ranjithan, R., Weitz, K. A., & Nishtala, S. R. (1995). *Life-Cycle Study of Municipal Solid Waste Management* (pp. 8–10). EPA.

Ben-Daya, M., & Raouf, A. (1996). A revised failure mode and effects analysis model. *International Journal of Quality & Reliability Manage- Ment,, 13(1),,* 43–47.

Bjarnadóttir, H. J., Friðriksson, G. B., & Sletsen, H. (2002). Guidelines for the use of LCA in the waste management sector, (TR 517).

Bovea, M. D., & Powell, J. C. (2006). Alternative scenarios to meet the demands of sustainable waste management. *Journal of Environmental Management*, *79*(2), 115–32. doi:10.1016/j.jenvman.2005.06.005

Bowles, J. B. (2004). An assessment of PRN prioritization in a failure modes effects and criticality analysis. *Journal of the IEST,*, (47,), 51– 56.

Brand G., Braunschweig A., Scheidegger A., S. O. (1997). Swiss Ecoscarcity, Weighting in Ecobalances with the Ecoscarcity Method - Ecofactors ,. German print available at the above web-adress;: BUWAL Series 297, 1998. Retrieved from english PDF available at docu@buwal.admin.ch or for download at http://www.e2mc.com/BUWAL297 english.pdf

Braungard, W. an. M. M. (2002). *cradle to cradle:Remaking the way we make things*. North Point Press.

BUWAL250. (1998). Life Cycle Inventory for Packagings, Volume I and II. Environmental Series No.250/I and II, Swiss Agency for the Environ- ment, Forest and Landscape (SAEFL), Berne, Switzerland.

Chang, C. L., Wei, C. C., & Lee, Y. H. (1999). Failure mode and effects analysis using fuzzy method and grey theory. Kybernetes, *28*, 1072–1080.

Chen, T.-C., & Lin, C.-F. (2008). Greenhouse gases emissions from waste management practices using Life Cycle Inventory model. *Journal of Hazardous Materials*, *155*(1-2), 23–31. doi:10.1016/j.jhazmat.2007.11.050

Cherubini, F., Bargigli, S., & Ulgiati, S. (2009). Life cycle assessment (LCA) of waste management strategies: Landfilling, sorting plant and incineration. *Energy*, *34*(12), 2116–2123. doi:10.1016/j.energy.2008.08.023

Chin, K.-S., Wang, Y.-M., Ka Kwai Poon, G., & Yang, J.-B. (2009). Failure mode and effects analysis using a group-based evidential reasoning approach. *Computers & Operations Research*, *36*(6), 1768–1779. doi:10.1016/j.cor.2008.05.002

Chu, T.-C. (2002). Facility location selection using fuzzy TOPSIS under group decisions,. *International Journal of Uncertainty, Fuzziness & Knowledge-Based Systems 10 (6)*, 687–701.

Coad, M. C. (2010). *Collection of Municipal Solid Waste in Developing Countries* (p. 200). United Nations: UN-HABITAT.

Coleen Castile, Alan Bedwell, Mike Sole, Mimi Drew, Jean Yon, Bill Hinkley, R. D. (2005). Guide to Best Management Practices 100 % Closed-Loop Recycle Systems at Vehicle and Other Equipment Wash Facilities. Retrieved from http://www.dep.state.fl.us/water/wastewater/docs/GuideBMPClosed-LoopRecycleSystems.pdf

Date, P. (2011). *Collection vehicle research and development*. Retrieved from www.wrap.org.uk

De Feo, G., & Malvano, C. (2012). Technical, economic and environmental analysis of a MSW kerbside separate collection system applied to small communities.

Waste Management (New York, N.Y.), *32*(10), 1760–74. doi:10.1016/j.wasman.2012.05.009

Device, E. S., Injection, D., Ratio, C., & Cleaner, A. (2010). ISUZU N-SERIES SPECIFICATION, *5*, 5–8.

Dobben H F, Schouwenberg E P A G, Nabuurs G J, P. A. H. (1998). *Biodiversity and productivity parameters as a basis for evaluating land use changes in LCA.* Annex 1 in Lindeijer E W,van Kampen M.

El-Haggar. (2004). *"Cradle-to-Cradle for Industrial Ecology",Advances in Science and Technology of Treatment and Utilization of Industrial Waste*. US-Egypt Joint Fund,CairoEgypt,: CMRDI and University of Florida.

El-Haggar, S. (2007). *Sustainable Industrial Design and waste Management,Cradle-to-Cradle for Sustainable Development*. Elsevier Academic Press.

EPA, E. P. A. (2006). *Solid Waste Management Greenhouse Gases:A Life-Cycle Assessment of Emissions and Sinks*. (3rd, Ed.). United States: Environmental Protection Agency.

G. Kim, C. P. and K. P. Y. (1997). Identifying investment opportunities for advanced manufacturing system with comparative-integrated performance. *Measurement, International Journal of Production Economics 50*, 23–33.

Geyer, R. (2011). *Life Cycle Impact Assessment: ESM 282, Industrial Ecology*. Bren School of Environmental Science and Management, University of California, Santa Barbara. Lecture.

Gilchrist, W. (1993). Modelling failure modes and effects analysis. *International Journal of Quality & Reliability Management,*, (10(5)), 16–23.

Goedkoop, & Spriensma. (1999). Eco-indicator 99. Retrieved from April, Goedkoop at al. check for updates at website (version http://www.pre.nl/eco-indicator99/

Guinée, J. (2002). Handbook on life cycle assessment operational guide to the ISO standards. *The International Journal of Life Cycle Assessment*, 687. Retrieved from http://kluweronline.com

Guinée, J.B. (Ed.), M. Gorrée, R. Heijungs, G. Huppes, R. Kleijn, A. de Koning, L. van Oers, A. Wegener Sleeswijk, S.Suh, H.A. Udo de Haes, J.A. de Bruijn, R. van D. and M. A. J. H. (2002). (Dutch) Handbook on LCA, Handbook on Life Cycle. Retrieved from http://www.leidenuniv.nl/cml/ssp/projects/lca2/lca2.html

H. Deng, C.-H. Y. and R. J. W. (2000). Inter-company comparison using modi¯ed TOPSIS with objective weights, Computers & Operations Research 27 (10), 963–974.

Hauschild and Potting, P. and H. (2004). EDIP 2003. Retrieved from http://ipt.dtu.dk/~mic/EDIP2003

I.J.LCA, J. I. (2003) in. (2003). LIME, METI, NEDO, AIST. Retrieved from http://www.jemai.or.jp/lcaforum/index.cfm

IPCC. (2007). IPCC Fourth Assessment Report (AR4) by Working Group 1 (WG1), Chapter 2 "Changes in Atmospheric Constituents and in Radiative Forcing" which contains information on global warming potential (GWP) of greenhouse gases. In *PCC Fourth Assessment Report (AR4) by Working Group 1 (WG1), Chapter 2 "Changes in Atmospheric Constituents and in Radiative Forcing" which contains information on global warming potential (GWP) of greenhouse gases*.

ISIPO. (2010). ISIPO, Iran Small industries & Industrial parks organization, Industrial advisers' data bank of the Ministry of Industries and Mines. Retrieved from http://www.sme.ir/?www.Tradedc.com

ISO 14001, I. (2006). *Environmental Management Systems: 2004 Self Assessment Checklist*. Retrieved from http://www.ncsi.com.au/downloads/ ISO14001SelfAssChecklist%28E0008%29.pdf

ISO 14040. (2006). Environmental management — Life cycle assessment — Principles and framework,ISO 14040.

ISO 14041. (1998). Environmental management -Life cycle assessment-Goal and scop definition and inventory analysis ,ISO 14041. International Standard Organisation.

ISO 14042. (2000). Environmental management-Life cycle assessment-Life cycle impact assessment-ISO 14042. The European Standard EN ISO 14042:2000.

ISO 14042. (2003). Environmental management — Life cycle impact assessment — Examples of application of ISO 14042, *2003*.

ISO 14043. (1998). *Environmental Management - Life Cycle Assessment - Life Cycle Interpretation ISO 14043*. International Standards Organization.

ISO 14044. (2006). Environmental management — Life cycle assessment — Requirements and guidelines, ISO 14044.

J. Sarkis, S. T. (2000). "A model for strategic supplier selection," Proceedings of Ninth Int Conf on IPSERA, 652–661.

J., T. R. S. (2002). Estimates of the damage costs of climate change.Parts I&II .Environmental and Resource Economics 21:47 & 135-160.

John.A.Boyd., P. P. R. K. F. J. (2008). *An introduction to sustainable development*. Island Publishing House.

Jolliet, & Mueller-Wenk. (2003). Impact 2002+A New Life Cycle Impact Assessment Methodology. Lausanne, GECOS, Swiss Federal Institute of Technology. Retrieved from http://www.epfl.ch/impact

Jolliet, O., Margni, M., Charles, R., Humbert, S., Payet, J., & Rebitzer, G. (2003). IMPACT 2002 + : A New Life Cycle Impact Assessment Methodology, *8*(6), 324–330.

K. Yoon. (1980). *Systems selection by multiple attribute decision making*. Kansas State University.

Khodro, I. (1974). Bardo,Irankhodro. Retrieved from http://www.motorshout.com/car/1986_iran_khodro_bardo/

Khodro, S. (1974). Z 24nb Zamiyad. Retrieved from http://www.gerdavari.com/mosh-zami.aspx

Liamsanguan, C., & Gheewala, S. H. (2008). LCA: a decision support tool for environmental assessment of MSW management systems. *Journal of Environmental Management*, *87*(1), 132–8. doi:10.1016/j.jenvman.2007.01.003

Ltd, I. B. S. (2013). Recycle bin. *Independent Bin Supplies Ltd*. Retrieved from http://www.wheeliebins.co.nz/bins.aspx

Ltd, T. P. (2006). *Sustainable Technologies"Life Cycle Analysis."* Retrieved from www.tececo.com/sustainability.life_cycle_analysis.php

Lund, H. F. (2001). *Recycling hand book* (the second.). Washington,D.C.: McGraw – Hill.

McDougall, F., White, P., Franke, M., & Hindle, P. (2008). *Integrated solid waste management: a life cycle inventory*. *Chemistry & ...* (p. 532). Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/cbdv.200490137/abstract

Mcmanus, M. (2010). Life Cycle Assessment: An Introduction, 20. Retrieved from www.pre.nl

Miyazaki, N., Siegenthaler, C., Kumagai, S., Shinozuka, E., Nagayama, A. (2003): JEPIX – The Japan Environmental Policy Priorities Index, Japan Science and Technology Inc./Sustainable Management Forum Japan, Tokyo./ in ENGLISH Miyazaki, N., Siegenthaler, , T. (n.d.). JEPIX, In JAPANESE: Retrieved from www.jepix.org

NAJI, I.P.E.I.S. (NAJI R. and D. C. (2010). NAJI, IRAN Police Electronic Information Services (NAJI Research and Development Corporation). Retrieved from http://epolice.ir/news.php

Narasimhan, R. (1983). An analytic approach to supplier selection. *Journal of Purchasing and Supply Management 1*, 27–32.

Nicholson, A. (2010). LCA allocation methods in open-loop recycling : incentivizing recycled material sourcing and creation of recyclable products, 1–16.

Ozeler, D., Yetiş, U., & Demirer, G. N. (2006). Life cycle assessment of municipal solid waste management methods: Ankara case study. *Environment International*, *32*(3), 405–11. doi:10.1016/j.envint.2005.10.002

P.Yoon, C. L. H. and K. (1981). *Multiple attribute decision making methods and applications, Springer,. Springer*. New York.

Pallant, J. (2011). *SPSS SURVIVAL MANUAL, A step by step guide to data analysis using SPSS* (4th ed., p. 354). Australia,Printed in China: ALLEN&UNWIN. Retrieved from www.allenandunwin.com

Pillay, A., & Wang, J. (2003). Modified failure mode and effects analysis using approximate reasoning. Reliability Engineering & System Safety, *79*, 69–85.

Potting, M. H. and J. (2003). Guidelines from the Danish Environmental Protection Agency Spatial differentiation in life cycle impact assessment The EDIP2003 methodology. Denmark.

Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., … Pennington, D. W. (2004). Life cycle assessment part 1: framework, goal and scope definition, inventory analysis, and applications. *Environment International*, *30*(5), 701–20. doi:10.1016/j.envint.2003.11.005

Rigamonti, L., Grosso, M., & Giugliano, M. (2009). Life cycle assessment for optimising the level of separated collection in integrated MSW management systems. *Waste Management (New York, N.Y.)*, *29*(2), 934–44. doi:10.1016/j.wasman.2008.06.005

Ross, S., & Evans, D. (2003). The environmental effect of reusing and recycling a plastic-based packaging system. *Journal of Cleaner Production*, *11*(5), 561–571. doi:10.1016/S0959-6526(02)00089-6

S.H. Zanakis, A. Solomon, N. W. and S. D. (1998). Multi-attribute decision making: A simulation comparison of select methods,. *European Journal of Operational Research 107 (3)*, 507–529.

SAIC, S. A. I. C. (2006). *LIFE CYCLE ASSESSMENT:PRINCIPALES AND PRECTICE*. EPA.

Sébastien Humbert, M. M., & Olivier, J. (2005). IMPACT 2002 + : User Guide. CH-1015 Lausanne, Switzerland.

Shafipur, R. (2001). I.R. of Iran Metrological Organization, Atmosferic Sicence and Metrological research Center,Research Council of Atmospheric Chemistry,Ozon and Air polution, The patern of basic data to study air pollution in cities,. Air Quality Control Co.

Snook, SH; Campanelli, RA; and Hart, J. A. S. of T. P. A. to L. B. I. J. O. M. 20(7):478-481. ERGONOMICS DEMONSTRATION PROJECT DEMONSTRATION PROJECT : SOLID WASTE MANAGEMENT AND (2004). Liberty Mutual Push/Pull. Retrieved from http://www.lni.wa.gov/wisha/ergo/demofnl/solidwasterecycling.pdf

Stamatis, D. H. (1995). Failure mode and effect analysis: FMEA from theory to execution. *Milwaukee, WI: ASQC Quality Press*.

Steen, S. and. (1999). EPS 2000d,. Retrieved from http://eps.esa.chalmers.se/

Tchobanoglous, G. (1993). *integrated Solid Waste Management:Engineering Principles and Management Issues* (pp. 291–300). New York: McGraw-Hill.

Team, W. R. T. and C. W. (2001). *climate Change*.

Tehran map. (2010). Retrieved from http://maps.thefullwiki.org/Tehran

Tehran Regional Electric, C. (2011). Monthly statistical report,, 4.

Thomas CD, Williams SE, Cameron A, Green RE, Bakkenes M, Beaumont LJ, Collingham YC, Erasmus BFN, de Siqueira MF, Grainger A, Hannah L, Hughes L, Huntley B, van jaarsveld AS, Midgley GF, Miles L, Ortega-Huerta MA, Peterson A T, P. O. (2004). *Biodiversity conservation:Uncertainty in predictions of extinction risk/Effects of changes in climate and land use/Climate change and extinction risk.Reply.Nature430(6995).*

Timmerman, E. (1986). An approach to vendor performance evaluation. *Journal of Purchasing and Supply Management 1*, 27–32.

UNEP. (1997). *"Cleaner Production at Pulp and Paper Mills:A Guidance Manual Publication in Cooperation with the National Productivity Council India."* United Nations Environmental Programme.

UNEP. (2006). *Background Report for a UNEP Guide to LIFE CYCLE MANAGEMENT-A bridge to sustainable products*. UNEP.

UNEP. (2010a). LCIA methodology. Retrieved from http://jp1.estis.net/includes/file.asp?site=lcinit&file=B322F28A-C1F0-4E21-8B14-982328A311D2

UNEP, U. N. E. P. (2010b). *Waste and Climate Change: Global trends and strategy framework*. United Nations Environmental Programme,Division of Technology, Industry and Economics International Environmental Technology Centre. Retrievedfrom http://www.unep.or.jp/ietc/Publications/spc/Waste&Climate Change/Waste&ClimateChange.pdf

UNEP/SETAC. (2005). *Life Cycle Approaches ,The road from analysis to practice* (first.). UNEP/SETAC. Retrieved from http://www.unep.fr/shared /publications/pdf/DTIx0594xPA-Road.pdf

US.EPA.SAIC, U. S. E. P. A. and S. A. I. C. (2001). *LCA 101- INTRODUCTION TO LCA* (p. 41). U.S. Environmental Protection Agency and Science Applications International Corporation. LCAccess. Retrieved from http://www.epa.gov/ ORD/NRMRL/lcaccess/lca101.htm.

V.P. Agrawal, V. K. and S. G. (1991). Computer aided robot selection: The multiple attribute decision making approach. *International Journal of Production Research 29 (8)*, 1629–1644.

Villanueva, a, & Wenzel, H. (2007). Paper waste - recycling, incineration or landfilling? A review of existing life cycle assessments. *Waste Management (New York, N.Y.)*, *27*(8), S29–46. doi:10.1016/j.wasman.2007.02.019

W. Klöpffer, J. Potting (eds.), J. Seppälä, J. Risbey, S. Meilinger, G. Norris, L.G. Lindfors, and M. G. (2001). *SETAC Europe working group on life cycle impact assessment. The report is published for the account of the Directiorate-General of the National Institute of Public Health and the Environment (RIVM), within the framework of project 550015.* (pp. 1–64). s (SETAC-Europe/STG-GARLIC): SETAC Europe Scientific Task Group on Global And RegionaL Impact Categories.

Waite, R. (1995). *Household Waste Recycling*. London: Great Britain.

Wenzel, & Hauschild. (1997). EDIP 97,. Retrieved from http://ipt.dtu.dk/~mic/EDIP97

WHO, W. H. O. (1982). *Rapid Assessment of Sources Air, water and land Pollution* (pp. 1–110). Geneva: World health Organization,.

William McDonough, M. B. (2002). *Cradle to Cradle: Remaking the Way We Make Things* (1st editio.). North Point Press.

William T. Fine. (2001). *Evaluation of environmental and occupational hazards,*. Retrieved from http://www.centrorisorse.org/evaluation-of-environmental-and-occupational-hazards.html

Winkler, J., & Bilitewski, B. (2007). Comparative evaluation of life cycle assessment models for solid waste management. *Waste Management (New York, N.Y.)*, *27*(8), 1021–31. doi:10.1016/j.wasman.2007.02.023

Woolridge, A. C., Ward, G. D., Phillips, P. S., Collins, M., & Gandy, S. (2006). Life cycle assessment for reuse/recycling of donated waste textiles compared to use of virgin material: An UK energy saving perspective. *Resources, Conservation and Recycling*, *46*(1), 94–103. doi:10.1016/j.resconrec.2005.06.006

Wu, C. P. and M. L. (1998). Process selection with multiple objective and subjective attributes, Production Planning & Control 9 (2), 189–200.

y Malcolm Moore, S. and J. H. (2011). One third of Chinese toys contain heavy metals'. Retrieved from http://www.wnd.com/2011/12/375761/

Y.-J. Lai, T.-Y. L. and C.-L. H. (1994). TOPSIS for MODM. *European Journal of Operational Research 76 (3)*, 486–500.

Zhongxing, W. (2013). Brown Kraft Paper Bag. Retrieved from http://www.alibaba.com/product-gs/347662792/2013_Brown_Kraft_F...

Zhuang, Y., Wu, S.-W., Wang, Y.-L., Wu, W.-X., & Chen, Y.-X. (2008). Source separation of household waste: a case study in China. *Waste Management (New York, N.Y.)*, *28*(10), 2022–30. doi:10.1016/j.wasman.2007.08.012