EVALUATION OF “NO PLASTIC BAG CAMPAIGN” IN SELANGOR AND BASIC DEGRADATION STUDY OF PLASTIC BAGS

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2017

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THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF TECHNOLOGY (ENVIRONMENTAL MANAGEMENT)

FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
KUALA LUMPUR

2017

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ABSTRACT

The "No Plastic Bag Day" campaign was triggered by plastic waste issue which is caused by its low degradability rate. However, the significance of the "No Plastic Bag Campaign" currently is still not known. Hence, the objective of this study is to fill the knowledge gap i.e. to conduct test on degradability rates of selected types of plastic bags in different mediums, to determine whether there are differences in the degradation between degradable and non-degradable plastics available in the market, to determine the awareness level of the public in Selangor on the "No Plastic Bag Campaign", to identify the willingness among the public to shop without plastic bags in Selangor, and to identify the influence of socio-economic background of the respondents on their willingness to shop without plastic bags. Soil burial test were conducted on selected types of plastic bags to determine its degradability by looking at the weight loss, changes on the surface morphology as well as alteration in functional groups of the plastic samples. On the other hand, survey was conducted in Selangor with sample size of 625 people. Non-degradable plastic bag in garden soil has the highest weight loss with 10.2% of weight loss after 120 days. All of the plastic samples showed some changes such as unevenness, roughness, cracks, holes and horizontal notches. In the Fourier transform Infrared (FT-IR) analysis, most of the plastic samples showed increase in the peaks' intensities through the whole burial period. From the survey it was found that 91.2% of the respondents are aware of the existence of the "No Plastic Bag Day" campaign and 74.1% responded positively to the discontinuation of plastic bag usage. 60% of those who are aware of the campaign are Malays and 61% of those who have received information on the danger of plastic wastes to the environment are female. 76.5% of the respondents have also taken the initiative to reduce the usage of plastic bags. Pearson correlation shows respondents' willingness to discontinue plastic bag usage to be correlated with their level of education. 50% respondents with higher

education background are supportive towards discontinuation of plastic bag usage and 60% without higher education are unsupportive towards it. It can be concluded that there is no significant difference in the degradation of all of the plastic sample and the burial medium did not play a significant role in the degradation rate. Also, majority of the public in Selangor are aware of the “No Plastic Bag Campaign” and are willing to shop without plastic bag. Their willingness to shop without plastic bag is influenced by their education background. Also, respondent’s socio-economic background has an influence on the respondents awareness and willingness to shop without plastic bag.

ABSTRAK

Kempen Hari Tanpa Beg Plastik telah tercetus akibat isu sisa plastik yang mempunyai kadar degradasi yang rendah. Namun, keberkesanan Kempen Hari Tanpa Beg Plastik masih tidak diketahui. Oleh itu, objektif kajian ini adalah untuk mengisi jurang pengetahuan tersebut dengan menjalankan ujian untuk menentukan kadar degradasi beg plastik yang terpilih di dalam medium yang berbeza, menentukan sama ada terdapat perbezaan dalam kadar degradasi di antara plastik terurai dan plastik tidak-terurai yang terdapat di dalam pasaran, kajian soal selidik menentukan tahap kesedaran orang ramai di Selangor mengenai Kempen Hari Tanpa Beg Plastik, mengenal pasti kesediaan orang awam di Selangor untuk membeli-belah tanpa beg plastik, dan mengenal pasti pengaruh latar belakang sosio-ekonomi responden terhadap kesanggupan mereka untuk membeli-belah tanpa beg plastik. Beg plastik yang terpilih ditanam di dalam media yang berbeza untuk menentukan keupayaan degradasi berdasarkan kehilangan berat, perubahan morfologi permukaan serta perubahan kumpulan berfungsi pada sampel plastik. Di samping itu, kajian soal selidik juga telah dijalankan di Selangor dengan saiz sampel 625 orang. Beg plastik tidak-terurai yang ditanam di dalam tanah yang diperoleh dari taman mencatat kehilangan berat yang tertinggi iaitu 10.2% selepas 120 hari. Semua sampel plastik menunjukkan perubahan seperti menjadi kasar, retak, berlubang dan pembentukan takukan mendatar. Dalam analisis FTIR, kebanyakan sampel plastik menunjukkan peningkatan dalam keamatan puncak sepanjang tempoh penanaman. Kajian soal selidik didapati bahawa 91.2% daripada responden mengetahui tentang Kempen Hari Tanpa Plastik Beg dan 74.1% telah memberikan maklum balas positif kepada pemberhentian penggunaan beg plastik. 60% daripada responden yang mengetahui tentang Kempen Hari Tanpa Plastik Beg terdiri daripada kaum Melayu dan 61% daripada mereka yang telah menerima maklumat mengenai

bahaya sisa plastik kepada alam sekitar adalah kaum wanita. 76.5% daripada responden juga telah mengambil inisiatif untuk mengurangkan penggunaan beg plastik. Korelasi Pearson menunjukkan kesediaan responden untuk tidak meneruskan penggunaan beg plastik boleh dikaitkan dengan tahap pendidikan. 50% responden dengan latar belakang pendidikan tinggi menyokong pemberhentian penggunaan beg plastik dan 60% tanpa pendidikan tinggi tidak menyokong. Kesimpulannya, tidak ada perbezaan yang signifikan dalam kadar degradasi ke semua tiga (3) jenis sampel plastik dan jenis medium tidak mempengaruhi kadar degradasi sampel beg plastik. Juga, majoriti orang ramai di Selangor menyedari tentang Kempen Hari Tanpa Beg Plastik dan bersedia untuk membeli-belah tanpa beg plastik. Kesanggupan mereka untuk membeli-belah tanpa beg plastik dipengaruhi oleh latar belakang pendidikan mereka. Latar belakang sosio-ekonomi responden juga mempunyai pengaruh ke atas kesedaran responden dan kesediaan mereka untuk membeli-belah tanpa beg plastik.

ACKNOWLEDGEMENTS

In the name of Allah the almighty, the most Beneficent and the most Merciful, I would like to express my deepest sense of gratitude to Allah. Only through the patience and hard work that Allah has blessed me, this thesis can be completed with bearable limitations.

I would like to take this opportunity to express my deepest gratitude to many special individuals for the enormous help they have given to me in completing this thesis. For their patience, guidance and endless support I wish to thank both of my supervisors, Dr. Fauziah Shahul Hamid and Dr. Firuza Begham Mustafa. My appreciation to my parents, Mohamad Shani and Noreham who were the ones that have encouraged me to further my studies in this field, and have given me unconditional love and support throughout the years. I am thankful for my husband Mohamad Alif who has been very patient in supporting me throughout this journey and more often acted as my own personal progress tracker by reminding me to stay focus on the research. Thank you for believing in me and often, more than I do myself.

I am also very grateful to the IPPP for providing me with the financial funds to carry out this research; Ms. Afzalina from Combicat, Mrs. Aidahani from the Physics department and Mr. Zaman from the Engineering Faculty who have assisted me in analysing my plastic samples; the library's staffs; the Faculty of Science's staffs; and the rest of University of Malaya's staffs who have in many ways involved or contributed in the completion of my thesis, no contribution is big or small enough for me not to acknowledge.

Special thanks to Mr. Imran from Worldwide Landfills who was kind enough to let me collect samples from the Jeram landfill; my lab mates Farah Aqilah, Emenike Chijioke and Aizuddin who were very kind in sharing knowledge, resources and most importantly for being a friend to me; and last but not least my dearest family and

friends, who were my cheerleaders that have kept my spirits up whenever things get tough. I am truly honoured and blessed to have crossed path with each one of you.

Also to every individual who have participated in my survey questionnaires, and contributed directly or indirectly in the completion of this thesis, thank you to all of you from the bottom of my heart.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

3D	:	Three-Dimensional
3R	:	Reduce, Reuse and Recycle
AAC	:	Adipic Acid Aliphatic
Al_2O_3	:	Aluminium Oxide
BPA	:	Bisphenol A
^0C	:	Degree Celsius
C-C	:	Carbon-Carbon Bond
CH_4	:	Methane
cm	:	Centimeter
Co	:	Carbon Monoxide
CO_2	:	Carbon Dioxide
Cr	:	Chromium
EUR	:	Euro
EVOH	:	Ethylene Vinyl Alcohol
Fe	:	Iron
FOMCA	:	Federation of Consumers Association Malaysia
Gal	:	Gallon
GESAMP	:	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GDP	:	Gross Domestic Product
H_2O	:	Water
HDPE	:	High-Density Polyethylene
IEA	:	International Energy Agency

IR	:	Infrared Spectroscopy
kg	:	Kilogram
KPKT	:	Ministry of Urban Wellbeing, Housing and Local Government
kV	:	Kilovolt
LCA	:	Life Cycle Assessment
LDPE	:	Low-Density Polyethylene
LLDPE	:	Linear Low-Density Polyethylene
MCC	:	Miri City Council
MDTCC	:	Ministry of Domestic Trade, Cooperative and Consumerism
MJ	:	Mega joule
ml	:	Milliliter
Mn	:	Manganese
Mo	:	Molybdenum
MPMA		Malaysian Plastics Manufacturers Association
MSW	:	Municipal Solid Waste
MYR	:	Malaysian Ringgit
NDRC	:	National Development and Reform Commission
NEA	:	National Environment Agency
NGO	:	Non-Governmental Organisation
Ni	:	Nickel
OECD	:	Organisation for Economic Co-operation and Development.
PBAT	:	Polybutyrate Adipate Terephthalate
PBS	:	Polybutylene Succinate
PBSA	:	Poly (Butylene Succinate-Co-Adipate)
PCL	:	Polycaprolactone
PE	:	Polyethylene

PET	:	Aromatic Polyesters
PETE	:	polyethylene Terephthalate
PHB	:	Polyhydroxy-Butyrate
PHB/V	:	Polyhydroxy-Butyrate-Valerate
PLA	:	Polylactic Acid
PP	:	Polypropylene
PS	:	Polystyrene
PVC	:	Polyvinyl Chloride
PVOH	:	Polyvinyl Alcohol
S1	:	Non-degradable plastic sample in garden soil
S2	:	Non-degradable plastic sample in compost
S3	:	Non-degradable plastic sample in landfill soil
S4	:	Biodegradable plastic sample in garden soil
S5	:	Biodegradable plastic sample in compost
S6	:	Biodegradable plastic sample in landfill soil
S7	:	Oxo-degradable plastic sample in garden soil
S8	:	Oxo-degradable plastic sample in compost
S9	:	Oxo-degradable plastic sample in landfill soil
SEM	:	Scanning Electron Microscope
SiO_2	:	Silicon Dioxide
SPSS	:	Statistical Package for Social Science
UNEP	:	United Nations Environment Programme
UNSD	:	United Nations Statistics Division
UV	:	Ultraviolet Radiation
VOCs	:	Volatile Organic Compounds

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

1.1 Overview

Plastics products are divided into two by industrial fabricators; “commodity” resins and “specialty” resins (“Plastic,” 2012). Plastic materials used for packaging purposes including plastic bags are made from commodity resins. Because plastic materials are widely used particularly for packaging purposes it is disposed on a daily basis by the users. Plastics that are disposed irresponsibly by users can be damaging to the environment and cause danger to humans’ health (Jacobsen, S., n.d).

Plastic materials thrown into the drain and/or rivers will eventually make their way into the oceans. Plastic materials pollute the water and can be toxic to sea life. It also tends to be mistaken by sea animals as food and when ingested can caused fatality. This may disrupt the sea life cycle and causes animal extinction in the long run.

Plastics have also been identified to be the cause for hormonal disruption in both wildlife and humans (“Taking back our stolen future,” 1996). Even if it does not enter the ocean it is thrown into the landfills. It will not degrade for hundreds or thousands of years and if it is burned it will release harmful toxic gases and increase the level of Volatile Organic Compounds (VOCs) in the environment (Wagner, J., n.d). Toxins are also released to the environment in the production of plastics which pollutes the air and are dangerous to living organisms (“Pollution and toxins,” n.d).

Production of plastic requires high level of energy. In the United States, 6% of energy used in the American Industry is for the production of plastic. In 1998, the plastic resin and plastic materials companies in the United States used up to 1,070 trillion of energy worth $6 billion (The Society of the Plastics Industry, Inc. & U.S. Department of Energy, 2003).

The amount of natural resources such as petroleum from fossil fuel for plastic production is very high. Plastic production used up 4% of global oil production and the current oil reserved of 1.24 trillion barrels is estimated to last for 41 years ("Oil consumption," 2008). 4% out of 1.24 trillion equivalents to 49.6 billion barrels of oil and it is a very big amount of oil to be used just for the production of plastics ("Oil consumption," 2008). These resources are non-renewable and depleting each day.

Non-renewable resources take millions to billions of years of geological processes to be renewed, thus it is depleting much faster than they are formed (Miller, 2004). Furthermore with the rapid human population growth of 1.26% (Miller, 2004), comes increasing demand of resources to fulfil increasing humans' needs. Looking at the exponential growth of human population, it is possible that one day the non-renewable resources will be completely depleted if humans continue using them unsustainably. This is the case for plastic production where petroleum mainly being used to produce packaging materials which are thrown away on a daily basis.

In Malaysia, generation of municipal solid waste (MSW) was reported to be 33,000 tonnes per day in 2012 with population of 28.3 million (Abdul Rahim, 2014). The estimated annual increase in developing countries is 2 to 3% every year (Suocheng et. al, 2002). Projected MSW generation to be approximately 9.82 million tonnes per year in 2020 and will keep on growing every year without fail if there is no action taken to properly manage these wastes (Anwar et al., 2012). Ministry of Urban Wellbeing, Housing and Local Government (KPKT) (2015) reported that there are 196 solid waste landfills available in Malaysia. However, only 165 are operational while the rest have been closed down (KPKT, 2015). Additionally, only 8 out of all the operational landfills are sanitary landfill (KPKT, 2015). The landfills which are currently in operation can take up to 29, 260, 000 tonnes of MSW (Anwar et al., 2012). With constant development, industrialization and growing populations in Malaysia, the number of landfills will not be enough to cater the increasing amount of MSW in the future.

Zaipul et al. (2015) reported that the solid waste comprises of 45% compostable organic waste such as food and the rest are paper (7%) and non-compostable waste such as plastic, glass and metal (Zaipul et al., 2015). Plastic made up 24% of waste in Malaysia, which is the highest amount for non-compostable waste (Zaipul et al., 2015). This alarming increase of plastic waste is a call for the government to reduce the consumption of plastic for the betterment of the environment and people.

Plastic waste is now a global issue and many countries and cities worldwide have taken action to overcome the issue by banning the usage of plastic bags. Among some of the countries are Eritrea, Kenya, Rwanda, Somalia, South Africa, Tanzania, Uganda, United States of America, Mexico, Taiwan, China, Australia, Italy, Britain, Bangladesh and India ("Mexico City bans," 2010; "Plastic bag bans," 2008). European countries like Republic of Ireland, Belgium, Switzerland, Germany and Holland have either imposed tax on plastic bag usage or charged for plastic bag ("Plastic bag bans," 2008). The action to ban the usage of plastic bags includes awareness campaign on the danger of plastic bags. It aims to educate the public on the danger of plastic bags to the health and environment, in view to decrease the usage of plastic bags by the society.

A nationwide campaign on "No Plastic Bags on Saturdays" was launched by the Domestic Trade, Cooperatives and Consumerism Ministry of Malaysia on the 1st of January 2011 (Dharmender, 2011). The campaign's theme is "Safe Our Future Generation and Earth" and it aims to reduce the effects that plastic shopping bag's usage had on the environment, economy and the health of consumers (Dharmender, 2011). The campaign's objective is to preserve the depleting resources and the environment while instilling environment friendly values among the businesses and public

(Dharmender, 2011). This is due to the alarming increase of solid waste in Malaysia in 2011 with an average composition of plastic (films) waste at 13.98%, the second highest after food/organic waste 37.98% (Anwar et al., 2012; Zainura et al., 2013). The campaign encourages the consumers to bring their own reusable shopping bags by charging 20 cents for a plastic shopping bag on Saturday. Initially, the campaign was only implemented in Selangor and Penang. However, with the projected increase of solid waste to 30,000 tonnes by 2020 in Malaysia, it has urged the government to launch the campaign nationwide (Dharmender, 2011).

However, it is difficult to comprehend the significance of the "No Plastic Bags on Saturdays" campaign without a study on its impact to the society, environment and economy. There is also no clear understanding on the best alternative option to the conventional plastic bag material which takes hundreds or thousands of years to degrade. Such study is important as it will gauge how much the campaign has managed to achieve its objective in reducing the amount of plastic waste in Malaysia and to provide people with the best alternative option to the conventional plastic bag.

1.2 Problem Statement

The issues associated with plastic bag waste that has sparked the nation to reduce usage of plastic bags are on its effect on the wellbeing of humans, animals and the environment, due to the nature of plastic bags that takes a long time to degrade in the environment. Plastic bags which are made of commodity resin bind by polymer chains are not biodegradable ("Plastic," 2012). Nonetheless, the components can breakdown with the presence of ultraviolet radiation (UV) from the sun in a process called photodegradation (Scheer & Moss, n.d).When exposed to UV, the polymer chains of polyethylene breaks resulting to plastic turning into microscopic synthetic granules

(Scheer & Moss, n.d). However, this process takes 10 to 100 years to complete (Scheer & Moss, n.d). Whether, the granules are completely decomposed is not known, it might build up in marine and terrestrial environment through food chain (Scheer & Moss, n.d).

Other than the long degradability period plastic bags production is also increasing in time. In 2013, 99 million tonnes of plastics were produced which shows 4% increase since 2012 ("Global plastic production rises," 2015). Due to that landfills are filling up quickly. "Global plastic production rises" (2015) reported 22% to 43% of the plastic used globally ends up in landfills. In Malaysia, security of disposal is no longer sustainable due to landfill space filling up earlier than scheduled (Agamuthu & Fauziah, 2011). It is also not just landfill is filling up with plastic waste, every year approximately 10 to 20 million tonnes of plastic goes into the oceans and it is estimated 268,940 tonnes of plastic made out of 5.25 trillion plastic particles are floating in the oceans ("Global plastic production rises," 2015).

Plastic waste thrown into the sea affects the marine life in three ways namely entanglement, ingestion and suffocation (James & Grant, n.d.). Plastic bags are confused by marine life to be food (such as jellyfish) and when swallowed by them can cause serious injuries and even fatality (Barry, 2009). When the plastic bag degrade and breaks down into smaller components, the toxic components such as bisphenol A (BPA) pollutes the sea water, thus potentially harms marine life (Barry, 2009). 267 species of marine life have been identified to be affected by plastic waste (Barry, 2009). The increasing amount of plastic waste in the sea which becomes pollutants is affecting the food chain (Barry, 2009). The concentration of the pollutants will continue to increase in the food chain because marine life that acquires plastic pollutants in their diet is eaten by other marine life or human being (Barry, 2009). It is a vicious cycle, when the marine life and human being die with the pollutants in their system it will eventually go back to the earth. Pollutants that accumulate in human body are also found to potentially cause cancer (Barry, 2009).

Plastic bags can potentially release greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4) to the atmosphere (Jacobsen, n.d.). Production, use and disposal of plastic bag releases carbon dioxide and methane (Boustead Consulting & Associates Ltd. (BCAL), n.d.). BCAL (n.d.) reported 40 tonnes of CO_2 were released from polyethylene manufacturing and 180 tonnes from compostable plastic bag manufacturing. Biodegradation is a process where compounds undergo biochemical transformation in mineralisation by microorganisms and releases either, water and carbon dioxide under anaerobic condition or methane and carbon dioxide under anaerobic condition (Baljit & Nisha, 2008).

The issues related to plastic bag wastes such as space limitation, threat to humans, animals and the environment, are growing with the growing number of plastic wastes. The growing number of plastic wastes in the environment outgrown the number of plastic waste being removed from the environment due to increase in production and low degradability rate. It is important to find an alternative to non-degradable plastic bag and a solution to reduce the amount of plastic waste being thrown into the environment as it is affecting the wellbeing of the environment, human and other living things.

In response to the environmental concerns biodegradable materials have been introduced to curb it (Huang et al., 1990). Plastics from biodegradable materials became the go-to solution due to popular belief that it has shorter degradability period and safer for the environment. However, there is insufficient data on the degradability period of degradable polymer and how it affects the environment (ExcelPlas Australia, Centre for Design (RMIT University) & Nolan ITU, 2004). Hence, there is a need for a comparison study on the degradability rates of different types of plastic materials available in the market.

While corporations are introducing alternative to conventional plastic materials to cater to the growing awareness on the impact of plastic to the environment, government bodies and environmental organisations around the world are banning the usage of plastic bags. The effort has been taken to reduce the usage of plastic bags and to create awareness on the danger of plastic bags to the environment. Cities and countries around the world have started such effort including Malaysia.

In this research the focus is on the "No Plastic Bags on Saturdays" campaign where the objective is to reduce the amount of plastic bag wastes in Malaysia. The campaign is, also aimed to create an environmentally conscious society with the right module and an impactful dissemination across Malaysia. Once the society is well educated on the issue, the support to reduce plastic bag usage will come naturally provided alternative materials are available and affordable to everyone. Even with the support from the society, government support remains vital in the initial stage of the campaign, throughout the implementation and post campaign to ensure its consistency and effectiveness.

Recognising the significance of "No Plastic Bags on Saturdays" campaign towards reducing the number of plastic waste and improving the quality of the environment and humans' health, there is a need for a study on the awareness level of the public and identification of the contributing factors towards the public willingness to shop without plastic bags.

In general, the topic deals with plastic waste and environmental awareness campaign. While the two areas of the topic may stand on its own, the areas indirectly relates to one another. The “No Plastic Bag Day” campaign is a direct respond to the issues related to plastic waste. It aims to create awareness and promote a more environmentally friendly behaviour within the public by discouraging the use of plastic bag and providing an alternative to plastic bag which is degradable plastic bag. However, there are many types of degradable plastic bag available in the market. Hence, the best selection of the alternative plastic bag needs to be considered. This study aims to identify the type of plastic bag that should be recommended as part of the campaign. Specifically this study will focus on the degradation of selected types of plastic bags and the awareness level of the public in all nine districts in Selangor on “No Plastic Bags on Saturdays” campaign. It will also discuss the influence of socio-economic background of the respondents on their willingness to shop without plastic bags.

1.3 Objectives of the Study

The objectives of the study are:

1. To conduct test on degradability rates of selected types of plastic bags in different mediums.
2. To determine whether there are differences in the degradation between degradable and non-degradable plastics available in the market.
3. To determine the awareness level of the public in Selangor on the “No Plastic Bag Campaign”.
4. To identify the willingness among the public to shop without plastic bags in Selangor.
5. To identify the influence of socio-economic background of the respondents on their willingness to shop without plastic bags.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Environmental problems the world is facing currently are complex and cannot be solved by implementing policies and laws alone. Miller (2004) described major environmental and resource problems as waste production, food supply problems, biodiversity depletion, air pollution and water pollution. One of the most discussed factors associated with environmental problems is the growth of world population.

2.2 World Population Growth

Since the birth of human, its population has been growing exponentially (Miller, 2004). As mortality started declining population growth began slowly, after the 17th or 18th century (Department of Economic and Social Affairs, 2011). After the industrial revolution until the 19th century world population growth has been significantly rapid, where it has reached one billion ("World population clock," n.d.). World population continues to rapidly grow in billions from 20th century to 21st century. It reached two billions in 130 years (1930), three billions in 29 years (1959), four billions in 15 years (1974), five billions in 13 years (1987), six billions in 12 years (1999) and seven billions in 12 years (2011) (National Research Council, 2000; "world population clock," n.d.).

From 1960 to 1970, the population growth rate was at its highest with 2% per year (Department of Economic and Social Affairs, 2011). Nonetheless, from the rate of annual population growth declines to 1.26% in 2003, and continues to drop to 1.16% from 2005 to 2010 (Miller, 2004; Department of Economic and Social Affairs, 2011). It is projected to continue to drop in coming years to 0.44% in the year 2045 to 2050 (Department of Economic and Social Affairs, 2011). Nonetheless, despite the forecasted drop in growth rate in the coming years the world population is projected to reach its first 9 billion in 2050 (Department of Economic and Social Affairs, 2011).

2.2.1 The impact of population growth on waste generation

Population growth impacted the world in many ways and is frequently related to environmental issues. Miller (2004) described population growth as one of the major environmental issues the world is facing other than, global climate change, increasing and wasteful resource use, pollution, biodiversity crisis, and poverty. Ehrlich & Holdren (1971) also concluded population control to be one of the solutions to reduce environmental degradation and needs to be worked on immediately. Another concern raised by Latifah et al. (2009) is how population growth leads to the increase of solid waste and causes the management of solid waste to be increasingly complicated. All of the issues are intertwined with each other, where one may be a direct impact of another issue. For example, increasing of resource use is the cause of deforestation where forest is converted for a different use.

Deforestation is often related to population growth as the increase of population increases the need for more land (Cropper, & Griffiths, 1994). Environmental quality is viewed to be degraded with the growing population. How population growth affects environmental quality is measured by forests reserve and the absence of air and water pollution (Cropper, & Griffiths, 1994).

Other than releasing greenhouse gases the human activities caused pollution. Miller (2004) defined pollution as addition to water, air, soil, or food that threatens humans or other living organisms' health, survival, or activities. Human activities such as irrigation and agriculture cause pollution and ultimately ecological disruption (Holdren & Ehrlich, 1974). Pollution caused by human activities mostly occurs near industrialised and urban areas (Miller, 2004).

Miller (2004) named poverty as one of the causes to environmental problems and relates it to growing population. As the population grows, the demand in food also increases to fulfil the growing needs of people. Food becomes more expensive as the demand increases and less affordable to the poor. Due to this, poor people will tend to degrade and deplete grasslands, forests, soil, wildlife and water supplies to survive (Miller, 2004). On the contrary, Clark (1967) argued that the main cause of environmental problems is not poverty, instead extremely fast increase of wealth in certain areas with growing population and urbanization.

Emmott (2013) discussed how the increase of consumption demands the increase of land use, agriculture, and production and transportation of consumable items. All of these activities contribute to the increase of methane, carbon dioxide and other greenhouse gases in the atmosphere (Emmott, 2013). Similarly, Satterthwaite (2009) discusses the connection between population growth and the increase in emission of greenhouse gases which resulted in climate change. Satterthwaite (2009) denies population growth to be the direct cause to the increase in greenhouse gases but relates it to consumer growth and the increase in consumption. Fulfilling consumer needs requires different types of human activities which in return add greenhouse gases to the environment. Human activities involve industry, energy supply, transport, residential/commercial buildings, waste and wastewater, and forestry and agriculture (Satterthwaite, 2009).

Human activities involving waste and wastewater impacted the environment in a few ways. Other than the fact that it releases greenhouse gases to the environment that leads to climate change, waste also causes different types of pollution, floods, leads to limited space problem, just to name a few (Asmawati et al., 2012; "Plastic bags fact sheet," 2009; "Toxic waste," n.d.). The impact that waste has on the environment is worrying as waste generation is increasing from time to time (Hoornweg & Bhada-Tata, 2012).

2.3 Waste

Waste generation and resource consumption are deemed to be closely related to environmental degradation (Fauziah, 2010). Before waste become a waste it was an item that was useful to people and was made from resources which sometimes can be renewable and non-renewable. Christensen (2011) states that solid waste is a waste in a solid state. Christensen (2011) also describes it as a leftover, or a redundant material or product which the owner wants to discard because it has no marginal value for the owner. Hoornweg & Bhada-Tata (2012) states that solid waste is accumulating even more rapidly than urbanization rate as it is the most imperative by-product of urban lifestyle.

Hoornweg & Bhada-Tata (2012) state that solid waste in particular is one of the most harmful local pollutants that causes local flooding and air and water pollution. Christensen (2011) describes solid waste as anything other than water (wastewater) and air borne (flue gasses) and includes solid, and liquid as sludge or in free chemical phase. Agamuthu (2001) defines solid wastes as unwanted wastes normally in the form of solid that arises from human and animal activities. The solid wastes are classified into four main categories; MSW, hazardous waste, agricultural waste and industrial waste (Agamuthu, 2001).

2.3.1 Waste generation

According to Hoornweg & Bhada-Tata (2012) the increase in economic development and urbanization rate are the driving factors of per capita increase in waste generation from 1.2 kg to 1.42 kg per person per day in the following fifteen years. Hoornweg & Bhada-Tata (2012) estimated global MSW generation to be 2.2 billion tonnes per year by 2025 which will double the amount of global MSW generation in 2012 at 1.3 billion tonnes per year (Hoornweg & Bhada-Tata, 2012). The increase in waste generation is translated into the increase of health and environmental risk (Department for Environment, Food and Rural Affairs (DEFRA), 2008).

In Malaysia, MSW generation has been increasing steadily with an annual increase of 2% due to rapid urbanisation and population growth (Zainura et al., 2013). In 2007, waste generation was 5.6 million per year which increases to 6 million tonnes per year in 2008, more than 8 million tonnes per year in 2010, and projected to be 9 million per year in 2020 (Zainura et al., 2013). 65% of the population is the urban population which is the major contributor to the waste generation (Agamuthu et al., 2009).

2.3.2 Waste composition

Solid waste is generated by all individuals at a different volume. The composition of waste generated by individuals is influenced by their lifestyle. Hoornweg and Bhada-Tata (2012) states the factors that influenced waste composition as economic development, culture, energy sources and climate. By identifying waste composition, wastes are able to be classified into different categories.

United Nations Statistics Division (UNSD) (2007) states two approaches to classify waste: activity-oriented breakdown and material-oriented breakdown. An example given by UNSD (2007) of activity-oriented breakdown is International

Standard Industrial Classification of all Economic Activities. The economic activities are similar to the human activities listed by Satterthwaite (2009). Material-oriented breakdown on the other hand is a classification of waste based on type of waste (UNSD, 2007). As discusses by Agamuthu (2001), waste composition in Malaysia are categorised into organic, paper, textile/leather, wood, plastic, rubber, glass, ceramics, ferrous metal, non-ferrous metal and others. Again, these may vary from one area to another depending on the human activities in that particular area.

Identifying and categorising waste composition is important to identify ways to manage it. Waste composition determined the type of disposal technology and waste treatment to be employed (Agamuthu, 2001).

2.3.3 Waste management

Solid waste management is a worldwide concern and it involves all individuals. Solid waste management has changed throughout the years and very much related to industrialization and lifestyle as it determines the types and composition of solid waste.

In managing solid waste, there are a few issues related to solid waste that needs to be taken into consideration. Christensen (2011) identifies issues associated with waste to be volume or space that waste occupies as waste do not vanish by itself, nuisance such as flies and bad odour caused by waste that is kept too long, aesthetic problems to the people living around the dump area, contamination of air, soil and groundwater, and public health issues due to pathogens transfer from waste to human and animal through direct or indirect contact such as water, air, insects and small rodents. All of the issues mentioned falls back to the failure to efficiently manage solid waste rather than the waste itself.

Solid waste management includes waste generation control, collection, storage, transport and transfer, processing, and disposing of solid wastes according to the best principles of environmental considerations, conservation, public health, economics, engineering, and aesthetics (Agamuthu, 2001). Christensen (2011) breaks down waste management into five categories and prioritised them according to the most preferred to the least preferred methods as shown in Figure 2.1

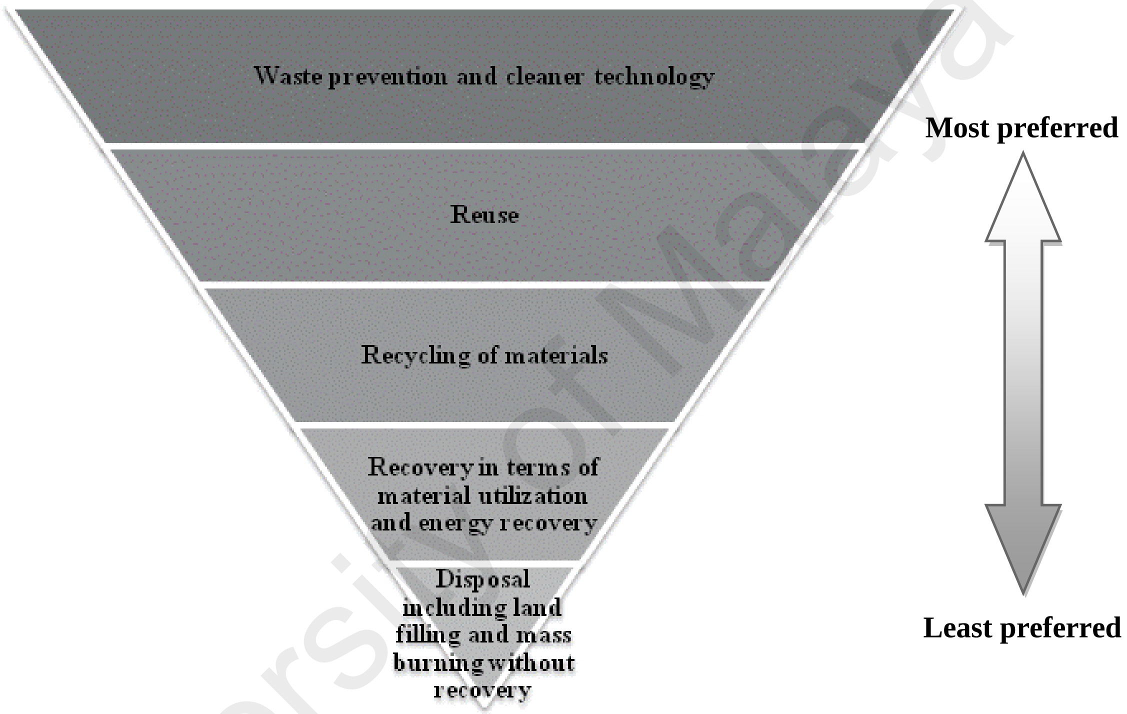


Figure 2.1: Waste Management Hierarchy (Christensen, 2011)

Waste prevention is a part of waste minimization which is to reduce waste at its source and it happens even before any products or materials are thrown away and become waste (Organisation for Economic Co-operation and Development (OECD), 2000). The purposes of waste prevention are first to reduce waste quantity and second is to increase the waste quality by reducing the danger of the waste (Christensen, 2011). Hoornweg & Bhada-Tata (2012) compare waste prevention activities between low income, middle income and high income countries as follows:

a) Low Income: lack of organised programs, nonetheless per capita waste generations rates are low and the practise of reuse is common,
b) Middle Income: some discussion on waste prevention activities, however lack of organised programs,
c) High Income: available organised education programs focus on reduce, reuse and recycle (the three "R"s). Also producers are more responsible with emphasize on product design.

Waste prevention is the most preferred method in the waste management hierarchy because it decreases the amount of waste and directly reduces the cost to manage it. The cost of waste management is not cheap. Solid waste management cost is $205.4 billion globally and is predicted to rise to approximately $375.5 billion in 2025 (Hoornweg & Bhada-Tata, 2012). According to Christensen (2011), the annual cost of solid waste management in metropolitan areas in Europe can total up to 100 euro per person which equals to 0.5% of the GDP. In Malaysia, adopting seven mini-incinerators to dispose hazardous waste have cost the country MYR 17 million (EUR 3.3 million) (Abdullah, 2001). Nonetheless, the cost to manage the waste properly is still lesser than the down-stream cost of poorly managed waste (Hoornweg & Bhada-Tata, 2012). Hence, the prevention of waste generation and proper waste management are the way to go.

The "No Plastic Bags on Saturdays" campaign falls under the waste prevention category in the waste management hierarchy. The campaign focuses on reducing plastic bag consumption and saving the environment by promoting the usage of reusable bag that has a longer life span (Irina et al., 2013). Another initiative taken to reduce the impact of plastic bag waste is to replace it with biodegradable plastic bag that have higher degradability rate than the conventional synthetic polymer bag (Ojeda et al., 2009). Both efforts of using reusable bag and biodegradable plastic bag to replace the conventional plastic bag aim to reduce the impact of plastic to the environment.

2.4 Plastic

Plastic are often linked to negative environmental impacts. There are numerous debates on the danger of plastic to the environment involving plastic manufacturers, government and environmental Non-Governmental Organisations (NGOs). Globally, approximately 288 million tonnes of plastics were produced in 2012 and 299 million tonnes were produced in 2013, which is an increase of 3.9% ("China leads global plastics production," 2014).

Due to its low degradability, synthetic polymeric plastic materials have been identified to accumulate in the environment at a rate of 25 million tonnes per year (Ojeda et al., 2009). It has been recognised that environmental pollution caused by synthetic polymers, such as water-soluble synthetic polymers and plastic waste in wastewater is a large problem (Shimao, 2001). In order to understand the impact of plastic to the environment it is essential to study plastic, how it degrades, its application and issues related to it.

2.4.1 The chemistry of plastic

Plastic is made from condensed fossil fuels with a mixture of hydrocarbon chains, which are fractured into repeating molecular units called "monomers" which then go through a process called polymerization where monomers are synthesised into polymers to form the base material (e.g. granulate or powder) which will finally go through numerous mechanical processes such as moulding and extruding to turn it into something useful (Christensen & Fruergaard, 2011). In raw form plastic is known as resin (Throne, 1979).

2.4.2 Classification of plastic

There are 100 over types of plastics available, however only six types of plastics are commonly used (National Solid Waste Management Department, 2011). Classification of plastics can be done based on their recyclability characteristics, thermal processing behaviour and structure (Christensen & Fruergaard, 2011; National Solid Waste Management Department, 2011).

Christensen & Fruergaard (2011) classify plastics based on its thermal processing behaviour and structure, and divide it into two main groups: Thermoplastics and Thermosets where the former are long chain of polymers and the latter are polymers in grid structure. Thermoplastic are more common among the two, easier to recycle and can be repeatedly softened with heat and hardened by cooling (Christensen & Fruergaard, 2011; Hourston, 2010). Thermoplastic can be divided into four subclasses; amorphous thermoplastics, rubber-modified amorphous thermoplastics, plasticised amorphous thermoplastics, and crystalline thermoplastics (Hourston, 2010). Examples of thermoplastics are polyethylene, polystyrene, polypropylene and polyvinyl chloride ("Polymers," n.d.).

Thermoset on the other hand is hard to recycle, and exceptionally resistant to heat, mechanical force, chemicals and wear, nonetheless it decomposes with heat (Christensen & Fruergaard, 2011; Hourston, 2010). Examples of thermosets are alkyds, amino and phenolic resins, epoxies, polyurethanes, and unsaturated polyesters ("Polymers," n.d.).

National Solid Waste Management Department (2011) classifies plastic into four categories based on plastic recyclability. Table 2.1 described the four plastic categories by National Solid Waste Management Department.

Table 2.1: Four Plastic Categories Based on Plastic Recyclability

No.	Type	Plastic Number	Descriptions	Examples
1	Easy plastics to recycle	1	Made of polyethylene terephthalate (PETE) and the most common and easiest plastic to recycle	Water bottles and medicine containers, and usually recycled into other plastic bottles, fibrefill for winter coats, life jackets, sleeping bags, bean bags, car bumpers, furniture, sails for boat, rope, cassette tapes, tennis ball felt and combs
		2	Made of high-density polyethylene (HDPE) plastics and widely accepted at recycling centres	Heavier containers to hold bleaches, laundry detergents, motor oil, shampoo and milk, and usually recycled into plastic lumber, piping, toys and rope
2	Plastics less commonly recycled	3	Made of polyvinyl chloride (Vinyl)	Shower curtains, medical tubing, plastic pipes, vinyl dashboards, and also some baby bottle nipples
		4	Made of low-density polyethylene (LDPE)	Sandwich bags, wrapping films and grocery plastic bags
		5	Made of polypropylene (PP) and due to its very low rate of recyclability only a few municipal recycling centres will accept these types of plastic	Containers for takeout meals, deli foods, margarine, and yogurt, bottle caps and closures, medicine bottles, fibres, and consumer products and appliances including automotive and carpeting
3	Useful plastics to recycle	6	Made of polystyrene (PS) and is widely accepted for recycling	Insulation, disposable cutlery, coffee cups and meat trays, and usually recycled into rigid foam insulation and cassette tapes
4	Hardest plastics to recycle	7 or sometimes may not be assigned with any number	Made from different combinations of the aforementioned plastics or uncommonly used unique plastic formulations, it is the most difficult to recycle and is rarely collected or recycled, nonetheless can be returned to the product manufacturers	All other type of plastic products that do not fit in plastic category 1 to 6

Source: National Solid Waste Management Department, 2011; “Plastics,” 2014.

Plastic bags are usually made of HDPE or LDPE which is under category 1 and 2 of easy to recycle and plastics less commonly recycled, respectively (Lajeunesse, 2004; Tooley, n.d). Plastic bags are also categorised as thermoplastic product which is easier to recycle as compared to thermoset products (Christensen & Fruergaard, 2011; Hourston, 2010).

2.4.3 Plastic bag

Sten Gustaf Thulin invented plastic bag at the beginning of the 1960s, patented in 1965 by Celloplast, and the patent was overturned by Mobil in 1977 ("Polyethylene 't-shirt' carrier bag," 2008). Plastic bag is commonly used to carry shopping items among consumers when doing their shopping regardless in wet market, supermarket or shopping malls. In Malaysia, plastic bag, packaging material such as wraps and hard packaging such as bottles represents the highest percentage of plastic products (46%) as compared to electric and electrical (16%), automotive (13%), construction (10%), household based products (9%), agricultural (3%) and others (4%) which comprised of products such as rope and pallets (National Solid Waste Management Department, 2011).

There are a few types of plastic bags available. The common types of plastic bags are usually made of HDPE, LDPE, and linear low-density polyethylene (LLDPE) (Lajeunesse, 2004). These plastic bags differ in terms of its physical properties and this is due to the degree of branching of the polymer chain (Lajeunesse, 2004). Table 2.2 shows the comparisons of the three types of polymers; HDPE, LDPE and LLDPE.

Table 2.2: Comparisons of HDPE, LDPE and LLDPE

Types of Polymer	Degree of Polymer Chain Branching	Density (g/cm3)	Physical Properties	Examples
HDPE	Very minimal	0.941 - 0.965	• High tensile strength • High crystallinity • Rigid, least flexible	Grocery bags
LDPE	Very high	0.910 - 0.925	• Low tensile strength • Low crystallinity • Flexible	Dry cleaning garment bags, plastic wrap, and sandwich bags
LLDPE	High (short branches)	0.910 - 0.940	• Higher tensile strength than LDPE • Higher crystallinity than LDPE • Very flexible	Thick and glossy shopping bags

Source: HDPE, LDPE, 2013; Lajeunesse, 2004; "What are the differences," 2008.

2.4.4 Degradable plastic bag

In the 21st century, a new kind of plastic bag called degradable plastic bags is made popular. Degradable plastic bags were introduced when the growing amount of plastic bags and its harm were made known. The introduction of degradable plastic bag is deemed to be the solution to the issues surrounding conventional plastic bags such as disposal problems, pollution caused by accumulation in the environment, potential shortage of fossil origin raw materials and aesthetic issues (Botelho et al., 2004; Gross & Kalra, 2002; Johnson, 2003).

Johnson (2003) uses definition of biodegradability preferred by the Society of the Plastics Industry's Degradable Polymers Council where for a material to be declared compostable or biodegradable it must fulfil ASTM tests by demonstrating 60% conversion to carbon dioxide for a single polymer, and for other materials 90% conversion to carbon dioxide in 180 days or less, and remain no more than 10% of the original weight on a 3/8 inches screen after 84 days (12 weeks).

There are many types of degradable plastic bag. Domb et al. (2011) divides biodegradable polymer into two categories; natural and synthetic origins. However, this categorization may be very wide and not specific. ExcelPlas Australia, Centre for Design (RMIT University) & Nolan ITU (2004) came out with two ways to categorise degradable plastic bags as the following:

a) The materials the plastic bags are made from. Such as synthetic polymers, natural starch polymers, or a blend of a conventional polymer with an additive to facilitate degradation.
b) The ways the plastic bags degrade whether through the action of microorganisms, the presence of heat, UV, mechanical stress or water.

The composition of degradable bags can be categorised into three main categories (ExcelPlas Australia, Centre for Design (RMIT University) & Nolan ITU, 2004):

a) Starch-polyester blends made from a mixture of thermoplastic starch with polyesters made from hydrocarbons.
b) Polyesters made from hydrocarbons (gas or oil). Different types of polyesters have different degradation rates. For example it can be weeks for aliphatic polyesters such as polyhydroxyalkanoates and decades for aromatic polyesters such as PET.
c) Thermoplastic starch-based polymers made from a minimum of 90% starch from renewable resources such as wheat, corn, potato or tapioca.

Degradable plastic bags may contain different types of degradable polymers. Degradable polymers can be categorised based on the composition pathway as listed in Table 2.3.

Table 2.3: List of Degradable Polymers Based on the Composition Pathway

No.	Type of Polymers	Descriptions
1	Biodegradable polymers	Able to decompose into water, methane, carbon dioxide, inorganic compounds or biomass through the means of microorganisms' enzymatic action.
2	Compostable polymers	Degradable under composting conditions. Which means it will only break down with the action of micro-organisms such as algae, bacteria, fungi, achieve total mineralization (conversion into water, methane, carbon dioxide, inorganic compounds or biomass under aerobic conditions) and the rate of mineralization must be compatible with the composting process and it must also be high.
3	Oxo-biodegradable polymers	Undergo accelerated oxidative define degradation (controlled degradation) with added "prodegradant" additives (additives that initiate and increase the degradation process) triggered by mechanical stress, heat and/or natural daylight. These polymers erode under the influence of weathering and brittle in the environment. The additive concentration in the plastic and the amount of sunlight and/or heat influence the time taken for the degradation process to happen.
4	Photodegradable polymers	Break down in the presence of UV light. The chemical structure of the plastic or the chemical bond in the polymer degrades with the presence of UV light and UV-sensitive additives in the polymer.
5	Water-soluble polymers	Dissolve in water within a certain temperature range and eventually biodegrade with the presence of microorganisms.

Source: ExcelPlas Australia, Centre for Design (RMIT University) & Nolan ITU, 2004; Thomas et al., 2010).

Degradable polymers can also be categorised based on the composition. Table 2.4 presents a list of degradable polymers categorised based on the composition.

Table 2.4: List of Degradable Plastic Bags Based on the Composition

No.	Degradable Polymer Type	Composition	From Renewable or Non -Renewable Resources
1	Biodegradable starch-based polymers	Thermoplastic starch derived from wheat, corn, or potato, mixed with additives such as plasticizers	Mostly renewable

Table 2.4: List of Degradable Plastic Bags Based on the Composition (cont'd)

No.	Degradable Polymer Type	Composition	From Renewable or Non -Renewable Resources
1	Biodegradable starch-based polymers	Thermoplastic starch derived from wheat, corn, or potato, mixed with polycaprolactone polyester polylactic acid (PCL or PLA)	Renewable starch component, however energy for agriculture and hydrocarbon-based plastics are non-renewable
		Thermoplastic starch derived from wheat, corn, potato, or tapioca, mixed with polyethylene	Renewable starch component, however energy for agriculture and hydrocarbon-based plastics are non-renewable
		Thermoplastic starch derived from corn, mixed with polyvinyl alcohol (PVOH)	Renewable starch component, however energy for agriculture and hydrocarbon-based plastics are non-renewable
2	Biodegradable polyesters	PLA	Renewable
		Polyhydroxy-butyrate-valerate (PHB/V)	Renewable
		Blends of Polyhydroxy-Butyrate (PHB) with PCL	Combination of renewable and non-renewable
		PCL	Non-renewable
		Adipic acid aliphatic/aromatic copolyesters (AAC)	Non-renewable
		Polybutylene succinate (PBS)	Non-renewable
		Polybutyrate adipate terephthalate (PBAT)	Non-renewable
		Poly (butylene succinate-co-adipate) (PBSA) copolymers	Non-renewable
		Modified PET	Non-renewable
3	Photodegradable polymers	Copolymers or thermoplastic synthetic polymers	Non-renewable
4	Controlled degradation masterbatch additives	PE mixed with a UV and/or thermal prodegradant additive	Non-renewable
5	Water soluble polymers	Ethylene vinyl alcohol (EVOH) and PVOH	Non-renewable

Source: ExcelPlas Australia, Centre for Design (RMIT University) & Nolan ITU, 2004.

Degradable plastic bags are highly degradable due to the presence of degradable compounds. Nonetheless, all types of plastic bags are recyclable and able to degrade. The differences are in the degradability rate, the way it degrades and the need for additives as some may not degrade on its own (Tolinski, 2011).

2.4.5 Plastic degradation

Subsequent chemical transformations and bond scissions caused by biological, chemical or physical reactions are known as plastic degradation or polymer degradation (Pospisil et al., 1998). There are a few factors that caused plastic degradation. Based on the various degradation factors plastic degradation are categorized into a few types: photo-oxidative degradation, thermal degradation, catalytic degradation, mechanochemical degradation, ozone-induced degradation, and biodegradation (Grassie & Scott, 1985).

UV light is one of the main sources of polymeric substrate damage under normal uncontrolled atmospheric and weather conditions (Singh & Sharma, 2008). Decomposition caused by the action of light is known as photo-oxidative degradation or photodegradation (Singh & Sharma, 2008). At the ether parts of the soft sections in polymers where it is most vulnerable to degradation, photo-irradiation forms ester, formate, aldehyde, and propyl end groups (Nagai et al., 2005). The energy in UV radiations is adequate to cleave C-C bond in polymer (Mark et al., 1986). Bonds present determined the most damaging UV wavelength for a particular plastic (Singh & Sharma, 2008). Hence, different types of plastics will undergo maximum degradation at different UV wavelengths (Singh & Sharma, 2008). For example, maximum degradation takes place at around 370 nm for polypropylene (PP) and around 300 nm for PE (Singh & Sharma, 2008). Photodegradation causes physical and optical changes in plastic such as yellowing, molecular weight change, and mechanical properties loss (Singh & Sharma, 2008). These changes affect the plastic mechanical integrity, strength and extensibility (Singh & Sharma, 2008).

Thermal degradation is almost similar to photochemical degradations where it falls under oxidative degradations (Singh & Sharma, 2008). However, the difference is at the sequence of the initiation steps of the auto-oxidation cycle under normal circumstances (Singh & Sharma, 2008). Another difference of these two reactions is photochemical reactions only take place on the exterior of the polymer sample (Tayler, 2004). On the other hand thermal reactions take place in the entire bulk (Tayler, 2004). Thermal degradation of polymers initiated by thermal and UV light happens through random and depolymerisation reaction either at initiator fragment, peroxide or ether link. Different types of compounds are produced from thermo-oxidative degradation for example CO_2, H_2O, formic acid, acetic acid, formaldehyde, acetaldehyde, hydroxyaldehydes, hydroxyacids and aldehyde acids (Boenig, 1964; Singh & Sharma, 2008). The chemical structure of polymer usually is not affected by thermal degradation, mostly only the quantity of degradation products are affected (Miskolczia et al., 2004). Nonetheless, the structure of the products can have a significant effect with increasing temperature and time, as the carbon atom distribution of the hydrocarbons obtained become wider (Singh & Sharma, 2008). At temperature above 200°C, thermal degradation can caused chain scission which mostly depends on impurities such as head-to-head units and unsaturation sites (Singh & Sharma, 2008).

Catalytic degradation is the degradation process with the presence of a catalyst for example zirconium hydride, zeolite catalysts, non-zeolite catalysts, transition metal catalysts such as Chromium (Cr), Molybdenum (Mo), Nickel (Ni), Carbon Monoxide (Co) and Iron (Fe) supported over Aluminium Oxide (Al_2O_3) and Silicon Dioxide (SiO_2), and Pt-Mo and Pt-Co supported over SiO_2 (Singh & Sharma, 2008). Catalytic degradation of plastic wastes into hydrocarbons has a high commercial value because the quality of products acquired from plastic wastes pyrolysis can be improved, the temperature of decomposition can be lowered and product selectivity is made possible (Singh & Sharma, 2008).

Polymer degradation occurs due to strong ultrasonic irradiations and mechanical stress assisted by a chemical reaction is known as mechanochemical degradation (Li et al, 2006). Mechanical stress include high speed milling or stirring (Singh & Sharma, 2008). Some ways of mechanochemical degradation are agitation, grinding or extrusions which will break the molecules in the polymer cause by the extremely powerful shearing force (Singh & Sharma, 2008). Polymer will lose its average molecular weight after going through mechanical degradation (Baranwal, 2003). According to Mark et al. (1986) free radicals were also produced by shearing, milling, grinding and shearing process as demonstrated graphically by an electronspin spectroscopy.

Ozone-induced degradation is caused by atmospheric ozone and occurred under normal circumstances where other oxidative aging progressions are exceptionally slow and the polymers maintain its properties for a relatively longer period (Cataldo et al., 2000). When polymer is exposed to ozone, the reactions will mainly occurs at the Carbon-Carbon (C-C) bond of saturated hydrocarbon links and aromatic rings and will rapidly and consistently forms a range of carbonyl, unsaturated carbonyl and aromatic carbonyl (Singh & Sharma, 2008). With increasing concentration and time, hydroxyl, ether, and terminal vinyl groups are formed gradually (Allen et al., 2003). Decomposition of macromolecules occurs when the reaction go through unstable intermediates like peroxy radicals or bipolar ion which can degrade or isomerise (Ghosh & Ray, 2004).

Degradation process caused by microorganism is known as biodegradation (Singh & Sharma, 2008). The microorganisms caused a biochemical transformation of compounds in mineralization (Singh & Sharma, 2008). By reducing microbial growth and increasing the polymers surface area for microbial growth the biodegradation process can be enhanced (Palmisano & Pettigrew, 1992). Under aerobic conditions, organic compounds' mineralisation release water and carbon dioxide, and under anaerobic condition it releases methane and carbon dioxide (Singh & Sharma, 2008). Biodegradation is identified according to a few mechanisms and can happen under one mechanism alone or with the combination of a few mechanisms together (Singh & Sharma, 2008). These mechanisms are surface properties alteration, degradation by enzymes, assimilation by microorganisms, breakage of backbone chain and mechanical strength, and average molecular loss of the polymers (Singh & Sharma, 2008).

2.4.6 Factors affecting plastic degradation

According to Singh & Sharma (2008), there are 11 factors affecting polymer degradation; chemical composition, chemical bonding, methods of synthesis, introduction of functionality, additives, effect of substituent, molecular weight, hydrophobic character, size of the molecules, effect of stress, and environmental conditions.

One of the most important factors that effects polymer degradation is chemical composition of the polymers. For example the presence of long carbon chains, unreactive methyl and phenyl groups make polymers non-susceptible to degradation. On the other hand the presence of heteroatom, unsaturation and amorphous regions makes polymers susceptible to degradation (Singh & Sharma, 2008).

Degradation in plastics is also influenced by its chemical bonding (Singh & Sharma, 2008). Crosslinking, branching, head-to-head linkage and tail-to-tail linkage in polymers influence the degradation rate (Singh & Sharma, 2008). Methods of synthesis have significant effect on the degradation rate of polymer (Gimouhopoulos et al., 2000). For example, compared to copolymerized polypropylene, polypropylene which is synthesized by ZieglereNatta Catalyst in bulk polymerization is more prone towards photodegradation (Tang et al., 2005).

Introduction of functionality such as carbonyl groups and moieties can make polymers more prone to degradation (Singh & Sharma, 2008). Additives such as non-polymeric impurities, pigments or fillers influenced degradability in polymers (Singh & Sharma, 2008). For example, metal such as Manganese (Mn) is a pro-oxidant additive that makes polymer susceptible for degradation (Singh & Sharma, 2008).

The increase in substituent on polymer backbone can reduce the polymer‘s thermal stability (Singh & Sharma, 2008). A lot of polymers contain labile α-hydrogen in its repeating units (Singh & Sharma, 2008). However there are certain types of substituent that increase thermal stability such as electronegative groups and aromatic groups (Gowariker et al., 2000; Seymour, 1971).

Plastic degradation rate increases with the decrease in molecular weight of the plastic (Kim & Kim, 1997). For example polyefins that has low molecular weight can be utilized faster by microorganisms compared to the ones with higher molecular weight (Yamada-Onodera et al., 2001; Santos et al., 2000).

Hydrophobic character and three-dimensional (3D) structure of petrochemical-based plastic makes it less degradable in the environment because these characteristics hinder microbial bio-film formation (Yamada-Onodera et al., 2001; Hadad et al., 2005). Similar to the molecular weight, as the molecule’s size decreases biodegradation, mechanical degradation, and thermal degradation increases (Gowariker et al., 2000).

Stress can affect degradation positively or negatively. Compressive stress hinders photodegradation rate on the other hand tensile stress boosts photodegradation (Singh & Sharma, 2008). Temperature, moisture, oxygen, and appropriate population of microorganisms are environmental conditions that affect polymer biodegradation (Orhan et al., 2004). Moisture content, higher temperature and the presence of oxygen in the environment promote degradation process (Singh & Sharma, 2008).

Soil burial test is a common tool used to determine plastic degradation caused by different factors. Müller (2005) recommends the test to be done in a controlled laboratory environment to control and adjust the external factor such as temperature, pH and humidity that influences the degradation process. Soil burial test is done for a period of time and degradation of materials is being observed at different time intervals.

Although degradable plastic bags are capable of degrading the time it takes for it to happen is long. During the time it takes to degrade it has already causes significant environmental impact.

2.5 Issues Related to Plastic Bag Wastes

Synthetic polymers which make up the conventional plastic bag accumulate in the environment faster than it degrades due to the increasing consumption rate. However, there is insufficient action to manage it properly. Plastic bag wastes that are not managed properly can caused environmental pollution and negatively affect humans, wildlife and its habitats ("Plastic pollution," n.d.).

Many animals such as birds and turtles mistaken plastic to be food, they get suffocated when digesting plastic materials or get entangled by plastic materials causing fatality (Gan, 2007). This can caused extinction problem especially to turtles which is an endangered animal in the world. Plastic waste can also contaminate groundwater and cause health problem to humans or animals that drink the contaminated water (Aggarwal et al., 2009). The increasing amount of plastic waste are taking up a lot of space in landfill and causing space problem ("Plastic bags," 2009). The production of plastic products emits dangerous greenhouse gases that contribute to global warming ("Plastic bags," 2009). Plastic waste is also causing aesthetic problem where public places become unattractive due to plastic littering (Agamuthu, 2001).

Worldwide plastics consumption adds up to 245 million tonnes per year, excluding polymers used as coatings, adhesives and other non-plastic applications (Organisation for Economic Co-operation and Development/International Energy Agency (OECD/IEA), 2009). However, only less than 10% of plastic waste is recycled from estimated plastic waste volume of 120 million tonnes, which is around 10 million tonnes (OECD/IEA, 2009). The rest of the plastic waste goes into incineration, energy recovery and landfilling (OECD/IEA, 2009). Energy used for plastic production may not be reduced through energy efficiency measures because most of the carbon from natural gas and oil is "locked" within the plastic product (OECD/IEA, 2013). Nonetheless, some of the "locked" energy can be recovered through incineration of the plastic waste (OECD/IEA, 2013). While recycling plastic is possibly the technology, less attention is given to this area due to lack of support from the government in the form of available waste policies.

Although there are clear evidences on the harm of plastic wastes to the environment, there are parties who do not believe that plastic wastes can cause negative health effects (Tolinski, 2011).

2.6 Contradictory Opinions on Issues Related to Plastic Bag Wastes

There are some parties that believe there is no need to ban plastic bags because plastic bags are not as harmful to the environment as it is claimed to be. In Malaysia, Malaysian Plastics Manufacturers Association (MPMA) (2010) discusses issues related to plastic bag by debunking differing facts that opposes the banning of plastic bags. The article presented some information from The Impact of Degradable Plastic Bags in Australia (ExcelPlas Australia, Centre for Design (RMIT University) & Nolan ITU, 2004) on degradation of plastic bags. ExcelPlas Australia, Centre for Design (RMIT University) & Nolan ITU, (2004) stated due to the oxygen-deprived and dry conditions usually found in landfills not just plastic bag but food and paper waste are also hardly broken down and are preserved. It also stated that degradable plastic bags degrade in aerobic condition by releasing methane gas which is a potent greenhouse gas that pollutes the air and causes global warming (ExcelPlas Australia, Centre for Design (RMIT University) & Nolan ITU, 2004). Plastic bag is also believed to be 100% recyclable and safe to the environment due to its inert non-toxic properties (ExcelPlas Australia, Centre for Design (RMIT University) & Nolan ITU, 2004). For example polyethylene which consists of hydrogen and carbon, hence it does not contribute to soil contamination, leaching to the groundwater or toxic emissions. (ExcelPlas Australia, Centre for Design (RMIT University) & Nolan ITU, 2004).

Another issue brought up with the banning of plastic bags by (MPMA, 2010) is the replacement of plastic bag with paper bag. It was stated that the usage of paper bag leaves even a bigger carbon footprint as compared to plastic bag (Brenton et al., 2010). Carbon footprint is the total amount of greenhouse gases emitted from an activity that impacts the climate change (Brenton et al., 2010). The article argued that the banning of plastic bag will increase the usage of paper bag leading to more trees being cut, increase of the usage of water and increasing emissions of greenhouse gases (Brenton et al., 2010). The article also shared a table of Life Cycle Assessment (LCA) calculation with comparison on the usage of energy, fossil fuel and water between Paper Compostable, Plastics and Polyethylene production (MPMA, 2010). LCA measures all parameters, starting from the early stage of the raw material (cradle) up to at the disposal stage which is its end of life (grave) (MPMA, 2010). From Table 2.5 it can be observed that compared to paper bags, plastic bag generate 60% less greenhouse gas emissions and uses 91% less energy to recycle.

Table 2.5: Life Cycle Assessment (LCA) Calculations Comparison between Paper, Compostable Plastics and Polyethylene (Plastics) Production

	Impact Summary		
	Carrying capacity (equivalent to 1,000 paper bags)		
Types of materials	**Paper**	**Compostable Plastics**	**Polyethylene (plastics)**
Total Energy Usage (MJ)	2,622	2,070	763
Fossil Fuel Use (kg)	23.2	41.5	14.9
Municipal Waste (kg)	33.9	19.2	7.0
Greenhouse gas (CO_2 equivalent tonnes)	0.08	0.18	0.04
Fresh Water Usage (gal)	1,004	1,017	58

Source: Boustead Consulting & Associates Ltd., n.d.

The “No Plastic Bag Day” campaign focuses on the usage of reusable bag to replace plastic bag and not paper bag however some retailers do provide paper bag as an alternative to plastic bag. Based on Table 2.5 the usage of paper bag may defy the purpose of the campaign. MPMA (2010) also questions the safety of using reusable bags by presenting a report by the director of research services at Sporometrics, Toronto, Canada, in 2009 where it stated that test findings support the fact that reusable bags if used to transport food can significantly jeopardise the safety of the food supply as it has the potential to become a breeding ground for yeast, bacteria, coliforms and mould, and an active microbial habitat (MPMA, 2010). Other than the report, the statement is not supported by any other data. The tested reusable bag may or may not been cleaned properly, if it is the later the usage of reusable bag is not a threat however it is the hygiene of the consumer.

MPMA (2010) also presented some information from Ireland and San Francisco which are some of the countries or cities that have instituted bring-your-own-bag policies, and levy or imposed a ban on plastic bags. In Ireland, a bag tax of 15 pennies (equivalent to approximately MYR 0.95) was imposed in 2002 resulting in 90% reduction in plastic bag use. However, the new policy causes the local production of plastic garbage bag to increase significantly to 400%. This is viewed as something negative as the consumers now have to pay for plastic bags to contain waste for disposal. In 2006, despite imposing tax, plastic bag is now charged 20 pennies per piece and currently the tax is being reviewed and they are considering increasing it from 20 pennies to 30 to 40 pennies (MPMA, 2010). However, there is no data shared on whether the increase of 400% production of garbage bag is more than the 90% plastic bag reduced from the tax imposed earlier. This is also because no alternative is introduced to garbage bag after the policy was introduced because the focus was only on retail plastic bags.

In San Francisco on the other hand, the usage of reusable bag was encouraged when plastic bags are banned in November 2007 (MPMA, 2010). However, in a survey conducted in September 2008 it was found that large numbers of paper bags were issued and only a few switched to reusable bags (MPMA, 2010). They also claimed that plastic composition out of the total amount of litter has increased from 0.60% to 0.64% after the banning which still makes up a very small portion of the waste.

MPMA (2010) also do not agree on the claim that production of plastic uses up a lot of energy. OECD/IEA (2013) reports 38% and the highest of the total energy consumption worldwide comes from manufacturing which includes plastic production, second is household with 29%, third is transport with 26%, followed by services with 9% and other with 3% (OECD/IEA, 2013). Petrochemical industry is the largest industrial consumer of energy with 34 exajoule (EJ) of energy usage in 2005 (OECD/IEA, 2013). Plastic represents the largest end-use of the industry (OECD/IEA, 2013).

MPMA (2010) suggested a better way of managing plastic waste is by implementing the 3Rs (reduce, reuse and recycle) principle instead of banning plastic bags. Behavioural problem also holds responsible for the littering problem of plastic bags. Plastic bags are also lightweight, hence are much more energy-efficient and sustainable in terms of the usage of energy resources.

Ehrlich & Holdren (1971) concluded that population control to be one of the solutions to reduce environmental degradation and need to be worked on immediately. Environmental degradation effects caused by population growth can also be reduced by modern technology and economic growth (Cropper & Griffiths, 1994).

Nonetheless, globally plastic bag banning campaign has been a common way to curb plastic waste issues. The effort is focused towards the reduction of plastic waste generation by instilling environmental awareness and knowledge on plastic waste. Creating environmental awareness is an important part of any plastic bag banning campaign and will be discussed further in the following subtopic.

2.7 Environmental Awareness

2.7.1 Environmental awareness definition

According to Macmillan dictionary awareness can be defined as knowledge or understanding of a subject, issue, or situation or the fact that someone knows about something, especially something bad. From the above definition it can be concluded that environmental awareness is the understanding of the natural world and the effect that human activity has on it.

Environmental awareness can be associated to the term environmentalism. According to "Environmental awareness" (n.d.) environmentalism is the "advocacy for or work toward protecting the natural environment from destruction or pollution" or "the theory that environment rather than heredity is the primary influence on intellectual growth and cultural development". Environmentalism can be concluded from the definition to be the act upon having environmental awareness.

Mitigating the environmental issues require individuals who have environmental awareness and understanding of the environmental problems before they could analyse the issues and translate the knowledge into informed actions. The informed action taken to decrease the negative impact of human's activity on the built and natural world is also known as pro-environmental behaviour (Kollmuss and Agyeman, 2002). One of the factors described in Kollmuss and Agyeman (2002), to influence pro-environmental behaviour are internal factors which include environmental knowledge and awareness. It is important to instil environmental awareness and provide environmental knowledge because without it, it is difficult to drive action to conserve and protect the environment. One of the ways to create environmental awareness and disseminate environmental education is by carrying out awareness campaign.

2.7.2 Environmental awareness campaign

The general purpose of an environmental awareness campaign is to educate people on certain environmental issue and to get them to change their behaviour to be more pro-environment. Creating environmental awareness and getting people to act on it are two related yet separate tasks. When people understand the environmental issue and its causes they will feel more empowered to do something about it. Their behaviour towards the environmental issue will also likely to change. However, this may vary from one individual to another as pro-environmental behaviour is influenced by a few factors. Nonetheless, carrying out awareness campaign is a common way taken by the government and also private sectors all around the globe to promote pro-environmental behaviour.

Carrying out environmental awareness campaign is as vital as identifying its effectiveness and whether it succeeds in achieving its objective. As the objective of environmental awareness campaign is to ultimately change the people's behaviour towards the environment it is vital to study the factors that influenced their behaviours.

All environmental awareness campaign aims to address environmental issues even though the focus may be different from one another. Each environmental awareness campaign has its own focus. It can be a very specific issue such as water pollution at Klang River or deforestation of rainforest in Malaysia and it can also be a broader issue that has a worldwide impact such as global warming.

Different types of activities conducted in an environmental awareness campaign ranging from indoor activities or outdoor activities depending on the focus of the campaign. For example a campaign that focuses on issue such as deforestation of rainforest in Malaysia may have activities such as tree planting, identifying flora and fauna in the rainforest and/or promoting usage of paper from planted trees rather than trees from the forest. All of the activities aim to educate and motivate the public to take action to tackle the issue.

The issues that have been related to plastic bag waste ranges from health, environment, economy, resource and space limitation. Activities that have been carried out in the campaign are banning the usage of plastic bag, promoting the usage of reusable bag, introduction of different types of degradable plastic bags, charging MYR 0.20 for a piece of plastic bag and channelling the money collected from the plastic bag sales to charities and environmental non-governmental organisations.

One of the earliest environmental awareness movements recorded is in the 14th century when King Edward I of England banned the burning of sea-coal for causing smoke problem (Alfred, 2011). Environmental pollution caused by the Industrial Revolution give rise to a bigger environmental movement in Europe and passing of the British Alkali Acts (1863) in Britain to mitigate the air pollution issue cause by the factories (Alfred, 2011). All of the movements are reaction to deteriorating conditions of the environment which are believed and some proven to have negative effects to the people whether immediately or in a long period of time.

In Malaysia, environmental awareness campaign is not something foreign. Environmental NGOs that existed in Malaysia since the 70s have been carrying out various environmental campaign around Malaysia ever since (Weiss & Saliha, 2003). Malaysians consist of people from different generations with different level of receptiveness to new knowledge. Thus, creating environmental awareness needs an approach that is customised to suit citizens of diverse demographic backgrounds. It also has to start at the earliest level and at a young age through exposure at home. Participation by all levels of public and groups in the community is important to raise environmental awareness and disseminate environmental education because everyone is part of the environment and carries out activities that have an impact to the environment.

Environmental awareness campaigns in Malaysia are carried out by various government bodies, NGOs and also private organisations. Depending on each entity's interest, environmental awareness campaign focus may differ. The focus varies on specific issues such as climate change, environmental pollution, resource depletion or waste management. One of the environmental awareness campaigns in Malaysia is the “No Plastic Bag Day” campaign. The research by Kuppusamy & Gharleghi (2015) revealed that the No Plastic Bag Day” campaign has a positive impact in the development on environmental behaviour in Klang Valley.

2.8 Plastic Bags Banning

2.8.1 The “No Plastic Bag Day” campaign in Malaysia

In Malaysia, plastic bag banning started in Penang with a campaign called “No Free Plastic Bags” in July 2009 (“Frequently asked question,” 2012). The banning started for one day in a week on Monday and extended to Tuesday and Wednesday in 2010 (“Frequently asked question,” 2012). In the same year Selangor also followed the footsteps of Penang by launching the “Say No to Plastic Bag” campaign on every Saturday (MPMA, 2010).

Initially, the campaign was only implemented in Selangor and Penang. However, with the projected increase of solid waste to 30,000 tonnes by 2020 in Malaysia, it has urged the government to launch the campaign nationwide (Dharmender, 2011). On the 1st of January 2011, the Domestic Trade, Cooperatives and Consumerism Ministry of Malaysia launched a nationwide campaign on “No Plastic Bags on Saturdays” (Dharmender, 2011). The “No Plastic Bags on Saturdays” campaign in Malaysia is an effort to support the government to save the environment and to educate public and businesses on environment friendly values (Dharmender, 2011). This campaign aims reduce the excessive usage of plastic bags (Irina, 2013). The campaign encourages the consumers to bring their own reusable shopping bags by charging 20 cents for a plastic shopping bag on Saturday (Dharmender, 2011).

In 2012, Penang launched “Every day is No Free Plastic Bags Day” campaign (“Frequently asked question,” 2012). In the same year, Selangor state government announced that they will add 2 more days namely Thursday and Friday to the “No Plastic Bag Day” campaign (Tang, 2012). Most recently the Selangor state government has announced that in 2017 the “No Plastic Bag Day” will be effective every day and not limited to plastic bag but also to polystyrene containers (“Selangor to ban,” 2016). Research by the state government revealed that 71% of Selangor residents expressed that conducting the campaign only on Saturdays to be insufficient (“Selangor to ban,” 2016).

The Malacca state government has also added another day in the banning of plastic bag making Friday and Saturday as plastic bag-free day (“'No Plastic' on,” 2014). The state government also banned selling of plastic bags on those days (“'No Plastic' on,” 2014). On the other hand, the neighbouring state which is Negeri Sembilan is not keen to follow the footsteps of Selangor as it is seen as burdening the people (“No ‘zero plastic bag’,” 2016). Menteri Besar Mohamad Hasan said the state government would prefer to educate the people on recycling instead of banning plastic bag (“No ‘zero plastic bag’,” 2016).

Johor state government has announced MYR 250,000 budget allocation in 2016 to carry out a study on biodegradation and biocompost under the Johor Blueprint (“No ‘zero plastic bag,” 2016). Johor state government is taking a step-by-step approach where they will start by extending the current practice of using biodegradable materials to replace plastic bags on Saturday to everyday starting June 2017 (“No ‘zero plastic bag," 2016). Johor state government will only start enforcing the full use of biodegradable materials in January 2018 ("No 'zero plastic bag," 2016).

Some renowned brands in Malaysia have also taken an independent movement to reduce the usage of conventional plastic bags. Many retailers such as Tesco, Giant, AEON, Caring pharmacy, Bread Talk and many others have switched to degradable plastic bags. With the launched of the "No Plastic Bag Day" campaign these companies have stopped giving out plastic bags every Saturday and will charge 20 cents if customer request for a plastic bag. The well-known Swedish home furnishing products store IKEA in Malaysia has completely ban the usage of plastic bag starting July 1st, 2011 ("Local efforts," n.d.). The customer has a choice to bring their own bag or buy IKEA's own blue reusable bag in three different sizes ranging from MYR1.00 to MYR1.90 ("Local efforts," n.d.). The campaign is also known as Bag for Life and the profits made from the sales of reusable bags are channelled to Malaysian Nature Society ("Local efforts," n.d.).

Although Malaysia started the plastic bag banning campaign in 2009, the campaign has been a worldwide practice since the early 90s (Al Gillespie, 2013). The following subtopic will discuss worldwide practice of the plastic bag banning campaign.

2.8.2 Plastic bags banning and management worldwide

Today, the banning of plastic bags has been a norm practice in many countries to reduce plastic bag wastes. According to Al Gillespie (2013) plastic bag banning started in Denmark over 20 years ago where excess packaging, including carrier bags are chargeable to the people. In 2001, Bangladesh followed through the effort by banning the production and sale of lightweight plastic bags after it was identified to be the cause of the 1988 and 1998 floods that caused two-thirds of the country to be underwater (Rupa, 2011). Due to the excessive use of plastics in Taiwan, the amount of plastic waste became hard to manage which leads the government to ban free distribution of disposable plastic bags and tableware in 2002 (“Taiwan’s plastics ban,” n.d.). Then, the cities in India and Australia started to ban plastic bags too (Al Gillespie, 2013).

India was also one of the earliest countries to ban plastic bag. In 2000, Mumbai started banning plastic bags followed by the Himalayan state of Himachal Pradesh where manufacturing, selling, and distribution of thinner bags were made illegal in 2003 (“Plastic bag bans,” 2008). The state of Maharashtra imposed full ban in 2005 and Chandigarh followed through in 2008 (“Plastic bag bans,” n.d.). The latest would be the biggest city in India, New Delhi which imposed the ban in January 2009 (“Delhi slaps blanket ban,” 2012). However, due to poor implementation it was not as effective as it was hoped to be (“Delhi slaps blanket ban,” 2012). In 2012, again the Delhi cabinet imposed similar but a more comprehensive banning of plastic bag (“Delhi slaps blanket ban,” 2012). The banning in Delhi includes not only sale, use and storage of plastic bag in the commercial area but also the use of covers, plastic sheets and films for packaging cards, books, or magazines, and manufacturing of plastic bags (“Delhi slaps blanket ban,” 2012). All types of plastic bags are included in the banning and the only exception is given to plastic bags under the Bio-Medical Waste Management and Handling Rules of 1998 (“Delhi slaps blanket ban,” 2012).

China is the next Asian country to ban plastic bag in 2008 (Inch, 2008). On July 11, 2008 the Ministry of Commerce in China announced changes to the plastic bag ban policy that was made effective on June 1st, 2008 to include restaurants, bookstores, and clothing stores (Inch, 2008). A government official from the National Development and Reform Commission (NDRC) reported 4.8 million tonnes of oil which is equivalent to

6.8 million tonnes of standard coal has been saved by China (Taylor, 2012). The country was also reported to have reduced the usage of plastic by 800,000 tonnes since the banning in June 2008 to June 2012 (Taylor, 2012).

In Australia, the communities of the Sydney suburb of Oyster Bay and Coles Bay in Tasmania, Mogo in New South Wales started to ban the usage of single-use bags since a decade ago (Martin, 2012). In 2009, the South Australian Government started to ban plastic bag completely (Martin, 2012). The Northern Territory and Australian Capital Territory did the same in 2011 (Martin, 2012). In 2012, The Tasmanian Government and Fremantle City followed suit (Martin, 2012). New Zealand, on the other hand is yet to adopt such banning. Nonetheless, Warehouse a leading brand in New Zealand has started to charge 10 cents per plastic bag (Al Gillespie, 2013). In 2012, $432,000 was collected from the movement and distributed to 68 community groups (Al Gillespie, 2013). Additionally, 500 tonnes of plastic managed to be reduced from the movement (Al Gillespie, 2013).

In the African region, South Africa was the first country to ban the usage of plastic carrier bags thinner than 30 micro-metres in 2003 (“South Africa bans,” 2003). Rwanda and Somalia then started banning single-use disposable plastic bags in 2005 (“Rwanda national bag ban,” 2013; “Somaliland bans,” 2005). Other countries in Africa that followed suit to ban plastic bags are Tanzania and Zanzibar in 2006, Kenya and Uganda in 2007, and Mauritania in 2013 (Pflanz, 2006; “Zanzibar islands ban,” 2006; “East African ban,” 2007; “Mauritania bans,” 2013).

Eight countries with the largest economies in the world namely Canada, France, Germany, Italy, Japan, Russia, United Kingdom, and United States have also taken interest in the issue of plastic bags waste management and some have also joined the movement of banning plastic bags (“Swiss parliament passes,” 2012). In the United

Kingdom and United States the total annual consumption has reached up to 300 plastic bags per person and for the rest of the European nations the consumption is close to 200 plastic bags per person (Al Gillespie, 2013). In 2011, Italy became the first country to outright plastic bag ban in Europe (Summers, 2012). France have banned plastic bag in November 2005 and to be effective as of 2010 ("France national," n.d.). However, France abandoned the plan in 2010 due to legal issues (Keating, 2012). Nonetheless, France's Ministry of Ecology Minister announced their plans to start banning plastic bags starting March 2016 ("France to ban," 2015). The first place in Britain to outlaw plastic bags in April 2007 was a town called Modbury located in Devon ("Plastic bag bans," 2008).

Another European country that has banned plastic bag is Switzerland. On 14th December 2012, a motion banning single-use plastic bags was approved by the Switzerland's Parliament, even though 99% of the country's plastic waste is currently either used for heating or electricity generation, or recycled ("Swiss parliament passes," 2012). A member of the lower chamber of the federal Parliament named Dominique de Buman introduced the motion to the Swiss Parliament on the basis of danger of plastic bags to the environment ("Swiss parliament passes," 2012).

In Germany, instead of banning plastic bags they are charged voluntarily ("Plastic bag reduction," n.d.). Other European countries that have also introduced charges to plastic bags are Belgium, Spain, Norway, Netherlands, Ireland, Denmark, Bulgaria, Portugal, Hungary, France, Holland and Wales (Al Gillespie, 2013; "Learn about," n.d; "Plastic bag reduction," n.d.; Roach, 2008). This is probably due to the potential legal and unemployment problems. Instead of banning the use of plastic bag the European Commission is finding ways to discourage single-use bags (Millner, 2012). A study by the commission reported banning plastic bags would have positive impacts to the environment however it would do the opposite for the economic (Millner, 2012). 250 to 300 plastic bag producers and 15,000 to 20,000 of their employees will be negatively impacted by the ban (Millner, 2012). The ban is also conflicting with EU international market rules and international trade law (Millner, 2012).

In the United States, San Francisco is the first to ban plastic bag (Sankin, 2012). However, the Save The Plastic Bag Coalition filed a lawsuit against the ruling, which argued a thorough report on the impact of the rule was not carry out by the city before it was passed by the San Francisco Board of Supervisors and signed by Mayor Ed Lee in early 2012 (Sankin, 2012). This did not stop other cities in the US like Austin, Los Angeles, New York City, Seattle, Washington D.C. and many other to follow suit the banning of plastic bags ("Where are plastic bags," n.d.). In Latin America, Mexico has banned plastic bag since 2010 ("Mexico City bans,"2010). Plastic bag was identified as one of the main causes of pollution in the country ("Mexico City bans," 2010). More than 20 million plastic bags per day are being used in Mexico and this has contributed for its pollution problem and blamed for many health and environmental hazards ("Mexico City bans," 2010).

In Toronto, Canada, 1,400 tonnes of plastic bags which equals to 215 million plastic bags are estimated to be used each year (Semple, 2012). Plastic bag was charged at 5 cent per piece in Toronto since 2009 before the motion to ban plastic bags was introduced (Jovanovski, 2012). However, the ban that was supposed to take place on January 1st 2013 was reversed by Toronto councillors in November 2012. This is due to the legal issue faced by the city when it is challenged by the Canadian Plastic Bag Association and Ontario Convenience Stores Association (Semple, 2012).

On the other hand in Russia, instead of plastic bags they were planning to ban PET bottles for beer packaging ("Russia overturns," 2012). However, in November 2012, they have abandoned the plan due to failure in proving the harm of PET bottles to human and the objection from the beer producers as most of their products are packed in PET plastic bottles (“Russia overturns,” 2012). The banning was also reversed because it would have a negative impact to the petrochemical industry in Russia (“Russia overturns,” 2012).

Japan on the other hand does not implement the banning of plastic bag but focused on recycling the waste instead. Since 1997, several recycling laws have been passed to address the treatment and disposal of plastic waste in Japan (McCurry, 2011). According to Japan’s Plastic Waste Management Institute, 77% of the plastic waste was recycled in Japan in 2010 (McCurry, 2011). Takushi Kamiya a spokesman from Japan’s Plastic Waste Management Institute, stated that the effectiveness of plastic recycling in Japan are due to the lack of space for landfill and support from the manufacturers to the waste- processing agencies (McCurry, 2011). According to the institute, 2.1 million tonnes of plastic waste were recycled in 2006 and 4.8 million tonnes went through thermal recycling which includes burning to generate energy and conversion into useful chemicals (McCurry, 2011). Japan does not recycle 100% of its plastic waste thus would still need to address the remaining plastic waste that is sent to landfill sites or incinerated (McCurry, 2011). However, it is the only country that recycles 77% of its plastic waste, which is twice more than that in the UK and 20% more than in the US (McCurry, 2011).

The United Arab Emirates has also banned all types of plastic bags except for oxo-biodegradables due to pollution and the risk it has over camels and other animals (Summers, 2012).

One of Malaysia’s nearest neighbouring countries, Singapore launched the “Bring Your Own Bag Day” on April 2007 (“Singapore: Say no to,” 2007). A study conducted by National Environment Agency (NEA) shows that 2.5 billion plastic bags are used by Singaporeans every year ("Singapore: Say no to," 2007).

Even many multinational corporations have made independent decision to ban plastic bags or impose charges for it, such as IKEA, Marks and Spencer, Whole Foods Market, Wal-Mart, and Target (Al Gillespie, 2013). Other, companies like Tesco from the United Kingdom has switched to biodegradable plastic bags (Roach, 2008).

Overall, the motivation of plastic bag banning is for the betterment of the environment, human beings and animals. The purpose of plastic bag banning is to keep plastic bags from polluting the environment whether in the form of litter or in the landfill (Roach, 2008). However, many have failed to impose the ban due to the failure of providing environmentally sound alternative to plastic bags such as reusable bag (Roach, 2008). Some countries like India and Bangladesh have faced the first hand setback from plastic bag waste which have caused those countries to experience bad floods that have destroyed many homes and even caused fatality (Reddy, 2011).

The success of plastic bag banning campaign is however uncertain. The following subtopic will discussed more on the effectiveness of plastic bag banning campaign.

2.8.3 Effectiveness of plastic bags banning campaign

Research done by Kamaruddin & Yusuf (2010) on motivation and acceptance level of 100 Selangor residents on the "No Plastic Bag Day" campaign revealed that 80% of their respondents are aware of the danger of plastic bags and 85% believe the campaign will help the environment. Another research by Zen et al. (2013) in the state of Johor to 262 Johor residents revealed that 94% of the respondents are aware of the campaign. Additional to that 66% know the impact the plastic bag campaign in reducing the amount of solid waste and how it will positively impact the environment (Zen et al., 2013). Also in Kamaruddin & Yusuf (2010), majority of 66% of the respondents in Selangor responded they are comfortable with the campaign launch however another 10% feels the campaign is launched not at the right time. The research done by Asmuni et al. (2015) which observed the level of store participation and consumer behaviours by 45 observers also revealed that majority of the cashiers took action to ask customer if they want plastic bag and informed them that they will need to purchase the plastic bag which shows the cashiers awareness on the campaign.

In terms of bringing own bag to shop, in the study by Asmuni et al. (2015) only a minority of 28.8% of the respondents bring their own bag to shop and majority of 47.7% still willingly purchase plastic bag. Similarly in Zen et al. (2013) majority of 60% of the respondents forgot three times or less to bring their own bag to shop on "No Plastic Bag Day". Additional to that a study by Kamaruddin & Yusuf (2010) also revealed a consistent finding where the respondents are not entirely keen to bring their own bag to shop with a mean score of 2.89 where 1 being strongly disagree and 5 being strongly agree to bring own bag to shop.

In Miri, the effectiveness of the campaign is doubted as plastic bag consumption was reported to have increased from 1,072,895 pieces in 2010 to 1,779,406 in 2011 since the campaign was launched ("Say no," 2012). However, Lawrence Lai the mayor of Miri stated that it is not fair to generally conclude the campaign failed to achieve its objective as the consumers showed their supports by bringing their own reusable bag when shopping ("Say no," 2012). A Memorandum of Understanding (MoU) was signed between Curtin University Sarawak (Curtin Sarawak) and the council to study the effectiveness of the campaign by Miri City Council (MCC) in November 2012 ("Say no," 2012). Lai also mentioned that the MCC would benefit from a proper study on the effectiveness of the campaign by Curtin University Sarawak (Curtin Sarawak) to gain accurate information and recommendation to the council ("Say no," 2012). There are a total of 13 participating outlets in Miri. However, some outlets which did not participate in the campaign also took advantage by charging the customers for plastic bags ("Say no," 2012).

The certainty of the collected fund being channelled to the right parties is also not clear. It was reported that MYR 372,614 has been collected between 2010 to November 2012. 50% were to be given to the council's Green Culture Fund (GCF) and another half of the fund would be given to the chosen charity organisations or Non-Governmental Organisation (NGO's) of the individual participating outlet (Say No, 2012). In an article by Malaysia Kini, Elizabeth Wong the Selangor executive Selangor stated that the MYR 0.20 charged on plastic bag in Selangor should be used for wildlife and environmental protection as what has been understood between hypermarkets and Ministry of Domestic Trade, Co-operatives and Consumerism (MDTCC) (Chie, 2017). On the other hand, MDTCC and supermarkets revealed that the money collected from charging plastic bag is being used for to conduct different activities in the supermarket (Convery et al., 2007; Dikgang and Visser, 2010; Romer, 2010).

On June 10 2012, the Federation of Consumers Association Malaysia (FOMCA) has suggested that the government impose fines on business premises that do not comply with the plastic bag banning to improve the effectiveness of the campaign ("Federation of Consumers Association Malaysia," 2012). FOMCA's secretary general, Muhammad Sha'ani Abdullah said it is important to have such measure to ensure the effort will not belittle by premises which will slow down the government's effort ("Federation of Consumers Association Malaysia," 2012). He also emphasised on the need to educate the public beforehand to avoid possible dispute ("Federation of Consumers Association Malaysia," 2012). The discussion between business operators and the public concludes that education and awareness campaigns should be implemented before imposing the fines ("Federation of Consumers Association Malaysia," 2012).

The effectiveness and success of the campaign to reduce environmental impact of plastic bag to the environment is still not clear. Continuous effort is needed to ensure the campaign manage to achieve its objective. Complementing the effort of educating the people on issues related to plastic bag and reducing plastic bag usage, there is also a need for a research on the best way to manage the current plastic waste.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This research consists of two main components namely; the degradation of selected plastic bags in different mediums and social survey on plastic bag usage. Both components are critical in achieving the objectives of this study. Soil burial test was used to identify degradability rates of selected types of plastic bag and the differences in the degradation between degradable and non-degradable plastics available in the market. The social survey on plastic bag usage was conducted to determine the awareness level, identify the willingness among the public to shop without plastic bags and the influence of socio-economic background of the respondents in Selangor on their willingness to do so. Both components of the research complement each other indirectly by providing insights to different ways to curb environmental issues related to plastic waste. One way is through providing alternative option to conventional plastic bag and the other is through creating environmental awareness and enforcing policies.

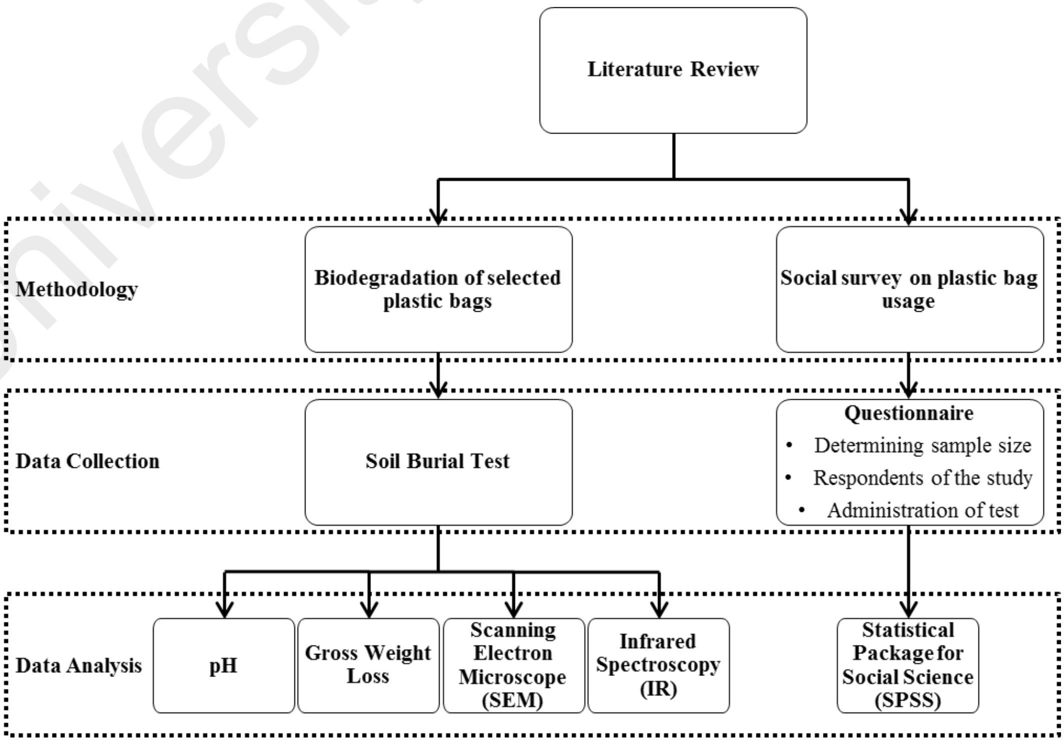


Figure 3.1: Research Methodology Flowchart

3.2 Degradation of Selected Plastic Bags

Plastic bag degradation rates were determined based on its gross weight loss, surface morphology alteration using Scanning Electron Microscope (SEM) and change in characteristics using infrared spectroscopy (IR). Three (3) different types of plastic bags are used in the degradation experiment:

a) Non-degradable plastic bag
b) Biodegradable plastic bag, and
c) Oxy-degradable plastic bag.

The plastic bags are collected from different retailers:

a) Sekoplas bought from AEON Mid Valley Megamall for non-degradable plastic bag,
b) AEON Mid Valley Megamall for biodegradable plastic bags, and
c) Caring Pharmacy Mid Valley Megamall for oxy-degradable plastic bag.

The plastic bags were selected based on its availability in the market. The three types of plastic bag are easily accessible in the market and have the most information on the type of plastic and its composition. The description of the plastic bag samples are summarized in Table 3.1.

Table 3.1: Details on Plastic Bag Samples Used in the Experiment

Plastic Bag Samples in Different Mediums			Types of Soil/Plastic Bag	Composition	Application	Source
Garden Soil	**Compost**	**Landfill Soil**				
S1	S2	S3	Non-degradable plastic bag	• HDPE	Shopping bag	Sekoplas
S4	S5	S6	Biodegradable plastic bag	• HDPE • LLDPE • Starch	Shopping bag	Carrefour
S7	S8	S9	Oxo-degradable plastic bag	• HDPE • LLDPE • Starch	Shopping bag	Caring Pharmacy

3.2.1 Soil Burial Test

Soil burial test was chosen to determine the degradation rate of the plastic samples because the test can be carried out under defined laboratory conditions. Defined laboratory conditions were chosen due to different types of medium being used and to control the temperature variable. This is also recommended by Müller (2005) in order to control and adjust the surrounding conditions that can influence the degradation process. The test enables monitoring of the biological activity based on different parameters (soil components, temperature, etc.) In this study, nine samples were prepared using three different types of plastic bags and three different types of medium. Each of the plastic samples were cleaned, cut into square-shape (5 centimeters (cm) x 5 cm), weighted, disinfected with 100% ethanol, and dried in the desiccators before being buried inside 1 to 2 kilogram (kg) of medium. The garden soil was bought from a nursery, compost was collected from vermicomposting experiment by one of the PhD students and the landfill soil was collected from Jeram Landfill. All of the collected mediums were kept in a plastic container in laboratory environment. The medium is placed in a 5 liter (l) plastic container with 22 cm x 14.5 cm width and 19 cm tall. The samples prepared were kept in laboratory condition with an average temperature of 20 to 25 degree Celsius (^{0}C) (room temperature). Each of the plastic samples was dug out at appropriate intervals (40, 80 and 120 days) and used for analysis on degradation.

3.2.2 Determination of the pH of the burial medium

Each type of burial medium (garden soil, compost and landfill soil) were air-dried, sieved and homogenized before analysis. The burial mediums were rewetted and incubated for 5 days at a temperature of 22 ^{0}C to recover the bacterial activity. 1 g of the burial mediums was weigh and mixed with 5 milliliter (ml) of distilled water. The mixtures were then placed on a shaker at the maximum intensity for 3 minutes to ensure they are well mixed. The burial mediums' pH was determined using a pH meter. This was done on Day 0 and repeated on Day 120 of the experiment.

3.2.3 Determination of the gross weight loss of the plastic samples

At three different time intervals (40, 80 and 120 days) plastic samples from the soil burial test were dug out carefully from the medium for analysis on degradation. The plastic samples were washed thoroughly in sterile distilled water and dried in the desiccator before being measured for their weight loss. The weight loss is measured using Acculab ALC-80.4 analytical balances. The weight loss measurements were repeated three times for each sample each time measurements were taken.

3.2.4 Determination of surface morphology alteration of the plastic samples using Scanning Electron Microscope (SEM)

After washing, drying and weighing a small piece of each plastic sample was cut into square-shape (0.5 cm x 0.5 cm) to fit into the electron microscope chamber. Then the plastic samples were mounted on aluminium stub using aluminium adhesive tape. Stub made of aluminium is used as it provides good supports for morphological studies. The specimens were then coated with a thin layer of gold as conductor at 2 kilovolt (kV) / 1 Ma / 3 minutes. After coating is done the plastic samples were scanned under electron microscope (SEM 525 PHILLIPS) at 8.50 kV acceleration voltages and observed under 2300x magnification.

3.2.5 Characterization by Infrared Spectroscopy (IR)

Again after washing, drying and weighing another small piece of each plastic sample was cut into square-shape (0.5 cm x 0.5 cm) to fit into the spectroscopy chamber. With spectrum performance from 400 to 4000 cm^{-1} the degradation each of the plastic samples were evaluated using Bruker Optics IFS 66 series Fourier transform Infrared (FT-IR) spectrometer. FTIR spectrometer is typically used for material characterization (Lowry, 2011). In this study, the different peak intensities in specific region of the spectrum from FTIR spectrometer will provide insights to the presence of material degradation process (Lowry, 2011).

3.3 Social Survey on Plastic Bag Usage

The survey instrument of this study uses convenient structured questionnaire to capture the actual awareness level and knowledge of respondents. Interview and data collection from a few related stakeholders in plastic waste management were also used to obtain other data and information that could not be obtained from the survey.

3.3.1 Determining sample size

The social survey study was done through questionnaires distribution to the public in urban, suburban and rural areas in Selangor. The targeted respondents are from all nine districts in Selangor. The total population aged 15 to 59 years old in Selangor is 3,675,088 ("Population distribution by local authority areas and mukims, 2010: Selangor," 2010). Sample size is determined using Yamane (1967) simplified formula with confidence level of 96% and confidence interval of 4. Based on the calculation using Equation 1, the sample size needed for Selangor are 625.

The formula used to get the sample size is as follows (Yamane, 1967):

<u>Equation 1</u>

$$n = 1 + \frac{N}{1+N(e)^2}$$

Where:
n = sample size
N = population size
e = confidence interval, expressed as decimal (e.g., .04 = ±4)

Calculation of the sample size for Selangor using Equation 1 is as follows (Yamane, 1967):

$$n = 1 + \frac{3,675,088}{1 + 3,675,088(0.04)^2}$$

$$n = 624.89$$

$\boldsymbol{n = 625}$

Selangor is divided into nine districts namely, Gombak, Klang, Kuala Langat, Kuala Selangor, Petaling, Sabak Bernam, Sepang, Ulu Langat and Ulu Selangor. The population size of each district was calculated to determine the number of respondents for the study.

The formula used to get the Calculation of sample size for each of the district in Selangor is as the following:

<u>Equation 2</u>

$$\text{Sample size of each district} = \frac{\text{District population}}{\text{Selangor population}}\ x\ n$$

An example of calculation for the sample size for Petaling using Equation 2 is as follows:

$$\text{Sample size of Petaling } = \frac{1,259,144}{3,675,088}\ x\ 625$$

$$\text{Sample size of Petaling } = 214.14$$

$$\textbf{Sample size of Petaling } = \textbf{214}$$

The sample of each district is summarised in Table 3.2.

Table 3.2: Sample Size for Nine (9) Districts in Selangor

No.	District in Selangor	Population in 2010 (‘000)	Sample Size
1	Petaling	1,259,144	214
2	Ulu Langat	797,958	136
3	Klang	572,340	97
4	Gombak	455,532	77
5	Sepang	139,580	24
6	Kuala Langat	138,958	24
7	Kuala Selangor	128,825	22
8	Ulu Selangor	121,219	21
9	Sabak Bernam	61,532	10
		Total:	**625**

3.3.2 Questionnaire

The survey questionnaire is divided into five sections and contains 49 questions:

a) Section 1: Background information

   This section provides demographics of the respondents participated in the survey. There are seven questions in this section in which the survey respondents can choose only one answer for each question. Demographics observed in this survey are place of residence, district of residence, age, gender, race, highest level of education, occupation and income.

b) Section 2: Knowledge on plastic bag

   This section contains nine questions on the respondents' knowledge on plastic bags wastes. Questions asked are on source of plastic bag, types of plastic bag, information on plastic bag wastes and issues related to plastic wastes. The questions were designed as multiple-choice questions with a few options. Questions 8, 10, 11, 14 and 16 allow the respondents to choose only one answer for each question. On the other hand, questions 9, 12, 13 and 15 allow the survey respondent to choose more than one answer.

c) Section 3: Plastic bag usage

   The 14 questions in this section look at the trend of plastic bag usage of the respondents which provides information on the respondents' plastic bag usage and preference on using plastic bag and alternative material. The information from this section helps to answer the third objective of the research which is to identify the willingness among the public to shop without plastic bags in all districts in Selangor. The questions consist of amount of plastic bag used daily, purpose of plastic bag usage, preference of using plastic bag, plastic bag disposal, initiative to use less plastic bag, using alternative materials other than plastic bag, opinion on continuation or discontinuation of using plastic bag, opinion on the party responsible to discontinue usage of plastic bag and support on using other types of waste management system. Questions 21, 22 and 29 are "Yes" or "No" questions. The rest of the questions are multiple-choice questions with a few options. Question 17, 25 and 27 allow the survey respondent to choose only one answer for each question and questions 18, 19, 20, 23, 24 and 28 allow the survey respondents to choose more than one answer.

d) Section 4: Awareness on the "No Plastic Bag Campaign"

There are 13 questions in total in this section. This section provides information to answer the second objective of the research which is to compare the awareness level of the public in urban, suburban and rural areas in Selangor on "No Plastic Bags Campaign". The questions revolves around the specific details of the "No Plastic Bag Campaign" from the launching date, objective, theme and other information related to the campaign. Question 30 and 32 are "Yes" or "No" questions. The rest of the questions are multiple-choice questions with a few options. Question 32, 33, 34, 36, 37, 38, 39 and 41 allow the survey respondent to choose only one answer for each question and questions 35 and 42 allow the survey respondents to choose more than one answer. Question 40 is an opinion based question where the survey respondent is required to write their opinion on appropriate cost for a piece of plastic bag.

e) Section 5: Opinion and attitude towards "No Plastic Bag Campaign"

This section consists of seven opinion based question on respondents' opinion and attitude towards the "No Plastic Bag Campaign" and banning of plastic bags. Questions 43, 44, 45, 47 and 48 require the respondents to choose one of the following options “Strongly agree”, “Agree”, ”Disagree” and “Strongly disagree”. Question 45 is a multiple-choice question allows the respondents to choose more than one answer. The last question in this section (question 49) requires the respondents to provide suggestion for improvement of the “No Plastic Bag Campaign” in Malaysia.

3.3.3 Respondents of the study

There are two requirements for the public to participate in the survey questionnaire, they are:

a) 16 years old of age and older, and
b) Reside in Selangor.

Other than the two requirements above, the public from diverse background were selected to participate in the survey questionnaire.

3.3.4 Administration of test

The survey was conducted through two methods

a) Online distribution

   100 questionnaires were shared with the survey respondents through email, Facebook and Twitter.

b) Face to face distribution

   525 questionnaires were distributed at different locations in all nine districts of Selangor. Commercial areas such as shopping malls, hypermarket and

supermarket were chosen as the focal point for distribution of the questionnaires due to the higher volume of people in the area. There is no time limitation needed for the survey, however a timeline of one week was given for the online distribution method to ensure respondent do not delay filling up the questionnaire.

3.3.5 Data processing and data analysis

Computer programme Statistical Package for Social Science (SPSS) was used to process the data collected from the survey questionnaires. Statistical significance and correlations of particular socio economic factors to knowledge on plastic bag and plastic wastes, plastic bag usage and awareness on the “No Plastic Bag Campaign”, awareness on the “No Plastic Bag Campaign”, and opinion and attitude towards “No Plastic Bag Campaign”, through Pearson Chi-square Correlation test were calculated.

CHAPTER 4: RESULTS & DISCUSSIONS

4.1 Introduction

The study was conducted to determine the degradation rates of selected types of plastic bags, as well as, to determine the awareness level of public on the "No Plastic Bag Campaign" in Selangor.

4.2 Plastic Degradation

4.2.1 pH of the burial mediums

Soil's pH is one of the most important factors in soil microorganisms' activity (Fernández-Calviño & Bååth, 2010). Table 4.1 shows the pH of the burial mediums namely garden soil, compost and landfill soil, respectively. Garden soil has pH range between pH 5.18 and pH 5.20. The highest pH readings were recorded for compost between pH 6.78 and pH 6.86. Landfill soil was recorded with the most acidic pH reading between pH 4.36 and pH 4.48. Compost has the most ideal pH for most microorganisms' activities. Optimum pH for microorganisms' activities is between pH 6.5 and pH 7.5 ("Growth requirements," n.d.). As for garden soil and landfill soil which are more acidic are ideal for acidophilic microorganisms' activities ("Growth requirements," n.d.). Microorganisms' activities in all three burial mediums will promote the degradation of plastic samples regardless of the pH readings. Mostafa et al. (2010) observed the degradation of plastic samples happened when buried in three types of mediums at pH 5.4 to pH 7.2. However, the rate of degradation may vary with different pH levels combined with other environmental factors such as biological activity, temperature and moisture.

Table 4.1: Average pH of Burial Mediums on Day 0 and Day 120

Time	pH		
	Garden Soil	Compost	Landfill Soil
Day 0	5.18 ± 0.01	6.86 ± 0.04	4.36 ± 0.06
Day 120	5.20 ± 0.01	6.78 + 0.04	4.48 ± 0.06

4.2.2 Determination of gross weight loss

After 40 days of burial, all nine plastic samples showed changes in weight. The weight loss recorded on Day 40 was between 0.4% and 3.8%. Biodegradable plastic sample in landfill soil (S6) showed the highest loss in weight on Day 40 with 3.8% weight loss as shown on Table 4.2. The lowest weight loss was only 0.3% for biodegradable plastic sample in compost (S5). Although both are the same type of plastic sample, the different properties of the burial medium may have influenced the degradation rate of both plastic samples. Similar observation was obtained in Mostafa et al. (2010) where five types of plastic samples were buried in three types of burial mediums, resulted in different degradation rates. According to Marana et al. (2014) the decrease in weight of plastic films in soil burial is a sign of degradation. This is also supported by Johnson (2003) where weight loss is taken as one of the most important criteria for biodegradable material.

Table 4.2: Average Gross Weight Loss of the Plastic Samples after 40 Days

Sample	Initial weight (g)	Final weight (g)	Weight loss (g)	Weight loss (%)
Non-degradable plastic sample in garden soil (S1)	0.0225	0.0220	0.0005	2.2222
Non-degradable plastic sample in compost (S2)	0.0228	0.0221	0.0007	3.0702
Non-degradable plastic sample in landfill soil (S3)	0.0222	0.0218	0.0004	1.8018
Biodegradable plastic sample in garden soil (S4)	0.0283	0.0280	0.0003	1.0601
Biodegradable plastic sample in compost (S5)	0.0285	0.0284	0.0001	0.3509
Biodegradable plastic sample in landfill soil (S6)	0.0288	0.0277	0.0011	3.8194
Oxo-degradable plastic sample in garden soil (S7)	0.0389	0.0382	0.0007	1.7995
Oxo-degradable plastic sample in compost (S8)	0.0372	0.0368	0.0004	1.0753
Oxo-degradable plastic sample in landfill soil (S9)	0.0387	0.0383	0.0004	1.0336

As shown in Table 4.3, all of the plastic samples showed weight loss of between 1.8% and 7% after 80 days buried in the selected medium. Similarly to Day 40, biodegradable plastic sample in landfill soil (S6) showed the highest weight loss of 7%. Biodegradable plastic sample contains starch component which is susceptible to microbial attack (Michael Gould et al., 1990).

The lowest weight loss recorded on Day 80 was for oxo-degradable plastic sample in compost (S8) with 1.8%. The degradation rate for oxo-degradable plastic sample is influenced by the presence of “prodegradant” additives, natural daylight, heat and / or mechanical stress (ExcelPlas Australia, Centre for Design (RMIT University) & Nolan ITU, 2004; Thomas et al., 2010). The fact that the plastic samples were kept in a laboratory environment where direct sunlight were limited and the temperature was lower than the natural environment, may have slowed down the degradation of oxo-degradable plastic samples.

Table 4.3: Average Gross Weight Loss of the Plastic Samples after 80 Days

Sample	Initial weight (g)	Final weight (g)	Weight loss (g)	Weight loss (%)
Non-degradable plastic sample in garden soil (S1)	0.0221	0.0210	0.0011	4.9774
Non-degradable plastic sample in compost (S2)	0.0225	0.0212	0.0013	5.7778
Non-degradable plastic sample in landfill soil (S3)	0.0221	0.0211	0.0010	4.5249
Biodegradable plastic sample in garden soil (S4)	0.0282	0.0268	0.0014	4.9645
Biodegradable plastic sample in compost (S5)	0.0282	0.0274	0.0008	2.8369
Biodegradable plastic sample in landfill soil (S6)	0.0286	0.0266	0.0020	6.9930
Oxo-degradable plastic sample in garden soil (S7)	0.0388	0.0371	0.0017	4.3814
Oxo-degradable plastic sample in compost (S8)	0.0382	0.0375	0.0007	1.8325
Oxo-degradable plastic sample in landfill soil (S9)	0.0388	0.0374	0.0014	3.6082

On Day 120, the weight loss for all of the plastic samples recorded was between 2.9% and 10.2%. Non-degradable plastic sample in garden soil (S1) showed the highest weight loss with 10.2% as shown on Table 4.4. This is perhaps due to the presence of more degrading microorganism and degradation enzymes as time goes by which promote the degradation of non-degradable plastic sample in garden soil (S1). Shimao (2001) reported the presence of certain degrading microorganism and degradation enzymes has caused the degradation of polymers. This is also perhaps due to temperature fluctuation in the laboratory that may have caused the non-degradable plastic sample to fragmentise into microplastics which are not visible to the naked eyes as similarly discussed in Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) (2015).

Table 4.4: Average Gross Weight Loss of the Plastic Samples after 120 Days

Sample	Initial weight (g)	Final weight (g)	Weight loss (g)	Weight loss (%)
Non-degradable plastic sample in garden soil (S1)	0.0215	0.0193	0.0022	10.2326
Non-degradable plastic sample in compost (S2)	0.0218	0.0196	0.0022	10.0917
Non-degradable plastic sample in landfill soil (S3)	0.0212	0.0196	0.0016	7.5472
Biodegradable plastic sample in garden soil (S4)	0.0293	0.0275	0.0018	6.1433
Biodegradable plastic sample in compost (S5)	0.0295	0.0275	0.0020	6.7797
Biodegradable plastic sample in landfill soil (S6)	0.0298	0.0273	0.0025	8.3893
Oxo-degradable plastic sample in garden soil (S7)	0.0389	0.0355	0.0034	8.7404
Oxo-degradable plastic sample in compost (S8)	0.0382	0.0371	0.0011	2.8796
Oxo-degradable plastic sample in landfill soil (S9)	0.0387	0.0366	0.0021	5.4264

Non-degradable plastic samples also undergone degradation process as other degradable plastic samples. This was observed with the recorded weight loss between 7.5 % and 10.2 % after 120 days of burial. This can be supported by Imai (1956) where it was identified that fungi can grow on n-alkane in polyethylene which makes it degradable. Also, even though polyethylene possess large molecular dimensions and has a hydrophobic nature, microbial attack can still occur after it undergoes a non-biotic degradation (Hueck, 1974). Tolinski (2011) also mentioned that all types of plastic bags are degradable. However, the degradability rate, the way it degrades and the need for additives as some may not be degradable on its own, are the differentiating factors from one plastic material to another.

Similar to Day 80, the lowest weight loss recorded on Day 120 for oxo-degradable plastic sample in compost (S8) was only 2.9%. The lack of sunlight and low temperature in the laboratory environment where the plastic samples are kept probably are the constraining factor to degradation of oxo-degradable plastic samples. This is aligned with the findings of Thomas et al. (2010), where a few studies proven that the degradation of oxo-degradable plastic is higher in sunnier areas such as the Middle Eastern region as compared to areas with temperate climate such as in Eastern Europe.

Figure 4.1 compares the weight loss of all plastic samples in three different types of burial mediums at three time intervals; Day 40, Day 80 and Day 120. Non-degradable plastic sample in garden soil (S1) showed the highest weight loss and oxo-degradable plastic sample in compost (S8) showed the smallest weight loss among all of the plastic samples after 120 days of burial.

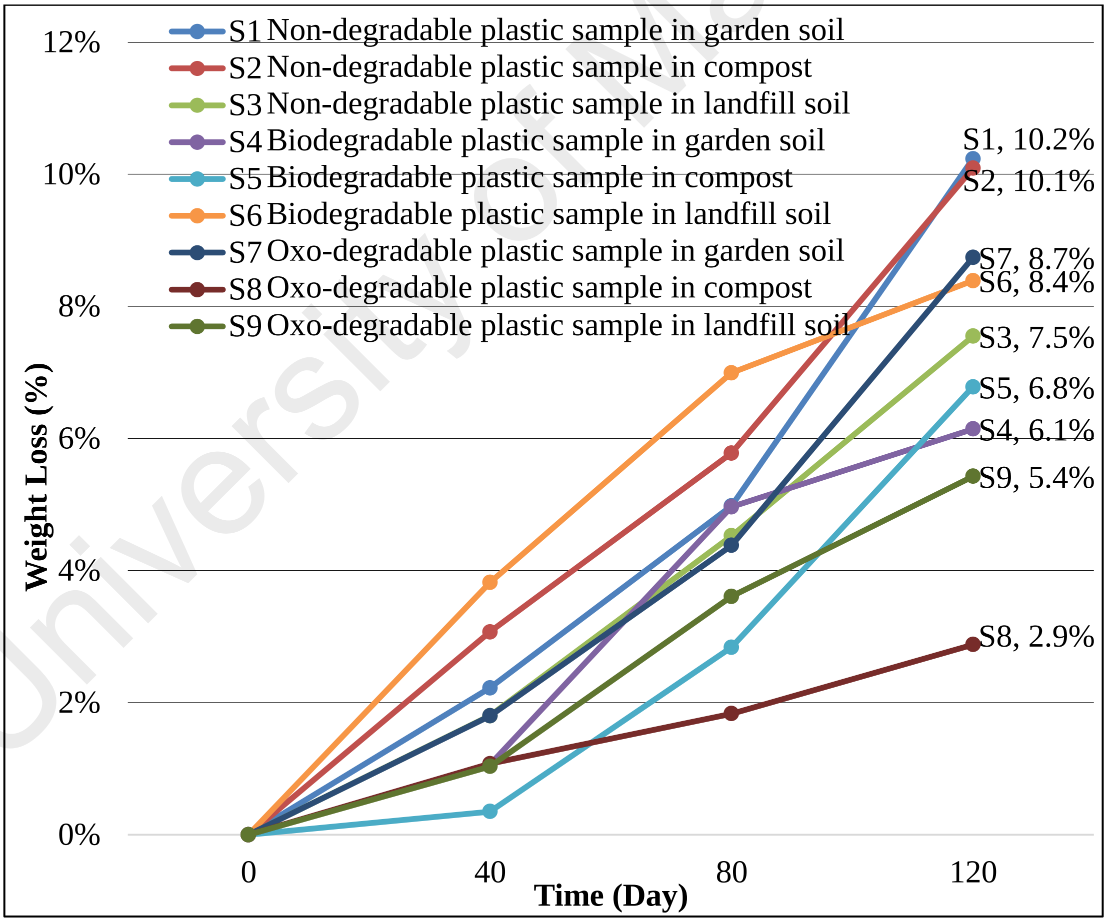


Figure 4.1: Weight Loss Comparisons of Different Types of Plastic Samples in Different Types of Burial Mediums

Linear regression was used to analyse the relationship of time interval with the weight loss of plastics. Table 4.5 shows that time interval is significantly correlated with weight loss of plastics (B = 1.000, t = 32.434, $p<0.05$, Adjusted R Square = 0.998). It means that with increasing time the weight loss will increase as well. Given longer burial period, better degradation rate can be observed in all of the plastic samples.

Table 4.5: Relationship between Time Interval and Weight Loss

Variable			
IV	Beta	t	Sig.
Time Interval	1.000	32.434	.020
R Square	.999		
Adjusted R Square	.998		

The degradation rate of plastic samples buried in the three burial mediums is presented in Table 4.6 as average percentage of weight loss. Based on the results, non-degradable plastic sample in garden soil recorded to have the highest degradation rate. The lowest degradation recorded is in oxo-degradable plastic sample in compost.

Table 4.6: Degradation of Plastic Samples Buried in Different Burial Mediums Based on Weight Loss Percentage

Types of Plastic Sample	Burial Mediums	Time (Days)			Average Weight Loss on Day 120
		40	80	120	
Non-degradable	Garden Soil	2.22 ± 0.65	5.00 ± 1.64	10.23 ± 1.99	9.29 ± 1.51
	Compost	3.07 ± 1.67	5.78 ± 1.63	10.09 ± 2.05	
	Landfill Soil	1.80 ± 0.64	4.52 ± 1.65	7.55 ± 2.10	
Biodegradable	Garden Soil	1.06 ± 0.90	4.96 ± 1.89	6.14 ± 1.56	7.10 ± 1.16
	Compost	0.35 ± 0.19	2.84 ± 0.99	6.78 ± 1.67	
	Landfill Soil	3.82 ± 1.83	6.99 ± 2.37	8.39 ± 1.38	
Oxo-degradable	Garden Soil	1.80 ± 0.85	4.38 ± 1.91	8.74 ± 2.01	5.68 ± 2.94
	Compost	1.08 ± 0.73	1.83 ± 0.86	2.88 ± 0.89	
	Landfill Soil	1.03 ± 0.77	3.61 ± 1.64	5.43 ± 1.02	

Figure 4.2 compares the average weight loss for all three types of plastic samples after 120 days of burial. Non-degradable plastic samples showed the highest weight loss with 9.3% and oxo-degradable plastic samples showed the lowest with an average weight loss of 5.7% after 120 days of burial.

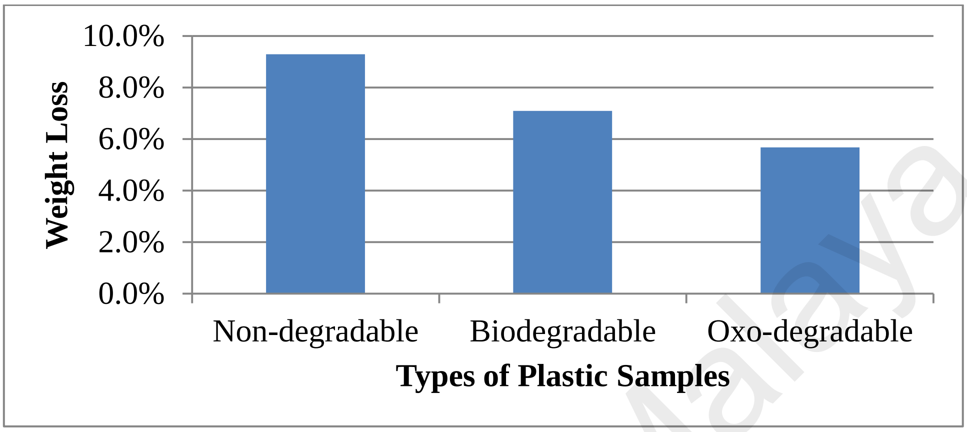


Figure 4.2: Weight Loss Comparisons of Different Types of Plastic Samples (%)

The reason why non-degradable plastic sample in garden has the highest weight loss among all plastic samples perhaps due to the higher presence of microorganisms in garden soil in which can caused degradation through biochemical transformation of compounds in mineralization (Singh & Sharma, 2008). However, this does not explain the lower degradation rate of biodegradable plastic sample and oxo-degradable plastic sample in garden soil. Biodegradable plastic sample recorded an average weight loss of only 7.1%. Perhaps this is influenced by the oxidation process that causes the increase of weight due to the formation of oxidative products (Koutny et al., 2006.).

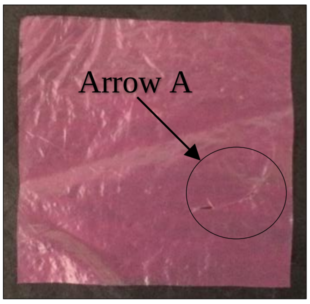
Oxo-degradable plastic sample had the lowest weight loss among all plastic samples. As discussed earlier in the Literature Review the presence of "prodegradant" additives, heat, natural daylight, and / or mechanical stress influenced the degradation rate of oxo-degradable plastic. For this study, the degradation rate may have been constrained by the lack of direct sunlight and the slightly low temperature in the laboratory set-ups.

Weight lost comparisons are the quickest and easiest way to measure degradations. However, weight loss comparisons alone may not be entirely reliable to measure plastic samples degradability. This is because the breakdown of polymer chain in plastic samples cannot be directly related to the increase and decrease of weight loss in polymer samples as discussed in Lucas et al. (2008). For example the decrease of plastic sample weight can be due to the disappearance of volatile and soluble impurities, and the increase of weight can be caused by the growth in number of microorganisms (Lucas et al., 2008). Hence, other observation on the plastic samples such as the physical changes, surface morphological changes and the changes in the chemical contents needs to be assessed for a better understanding on the degradation rate of different plastic samples in different burial mediums.

4.2.3 Physical changes of the plastic in the soil burial test

Most of the plastic samples did not show any obvious physical changes except for non-degradable plastic sample in garden soil (S1), biodegradable plastic sample in compost (S5) and biodegradable plastic sample in landfill soil (S6), on Day 120. Non-degradable plastic sample in garden soil (S1) showed a crack as shown on Table 4.7 and labelled as Arrow A. Non-degradable plastic sample in garden soil (S1) is made of HDPE which has high degree of crystallinity and makes it more prone to degradation (Tserkia et al., 2006). Non-degradable plastic sample in garden soil (S1) is also the lightest plastic sample and is more prone to degradation as molecular mass is one of the factor that influence degradation (Kim & Kim, 1997). This observation is also consistent with the weight loss recorded earlier, where non-degradable plastic sample in garden soil (S1) recorded the highest weight loss among all of plastic samples.

Table 4.7: Non-Degradable Plastic Samples on Day 0 and Day 120

Sample	Day 0	Day 120
Non-degradable plastic sample in garden soil (S1)		
Non-degradable plastic sample in compost (S2)		
Non-degradable plastic sample in landfill soil (S3)		

Degradation of biodegradable plastic sample in compost (S5) can be indicated with the formation of a tiny hole as shown in Table 4.8 and labelled with Arrow B.

Table 4.8: Biodegradable Plastic Samples on Day 0 and Day 120

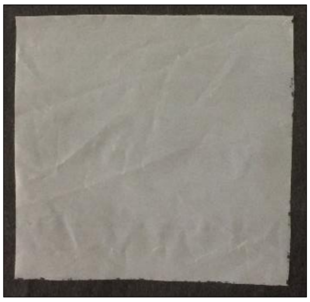
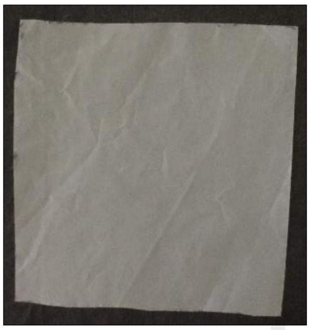
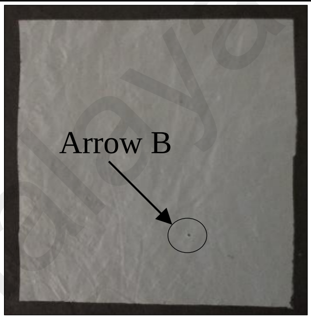
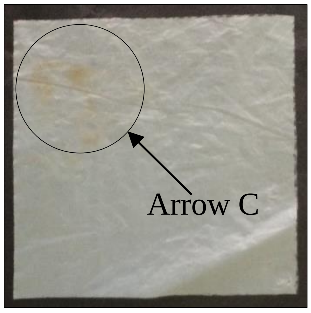
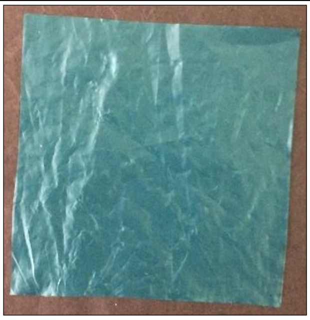
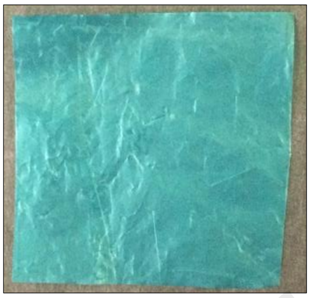
Sample	Day 0	Day 120
Biodegradable plastic sample in garden soil (S4)		
Biodegradable plastic sample in compost (S5)		
Biodegradable plastic sample in landfill soil (S6)		

Table 4.8 shows biodegradable plastic sample in landfill soil (S6) also showed a sign of degradation where discolouration can be observed on the sample labelled as Arrow C. Biodegradable plastic sample in compost (S5) was also buried in compost with average pH between pH 6.78 and pH 6.86, that is optimal for microorganism activities and may have promoted the degradation rate of the sample. These results are also consistent with the weight loss observed in both samples. These findings are also agreeable to findings reported by Ojeda et al. (2009). Biodegradable plastic have been recorded to record higher degradability rate than the conventional synthetic polymer bag

(Ojeda et al., 2009). Biodegradable plastic sample in compost (S5) and biodegradable plastic sample in landfill soil (S6) did not record the highest weight loss. This is perhaps due to the oxidation process which releases oxidative products and may have replaced the weight loss during degradation. Some of the physical changes indicate it is prone to degradation as compared to other plastic samples. Although there were very little physical changes recorded on the plastic samples at the end of the experiment, the weight loss recorded proves that all of the plastic samples went through degradation processes. The weight changes were too small to display physical changes that were visible to naked eyes. Perhaps with a longer burial period, more degradation can take place and obvious visible physical changes can be observed.

Degradation of oxo-degradable plastic sample in all three types of mediums (S7, S8 and S9) is not apparent by its physical changes due to the lack of "prodegradant" additives, natural daylight, heat and / or mechanical stress (Table 4.9). These factors influence the degradation rate of oxo-degradable plastic sample, that the lack of it discourages degradation activities.

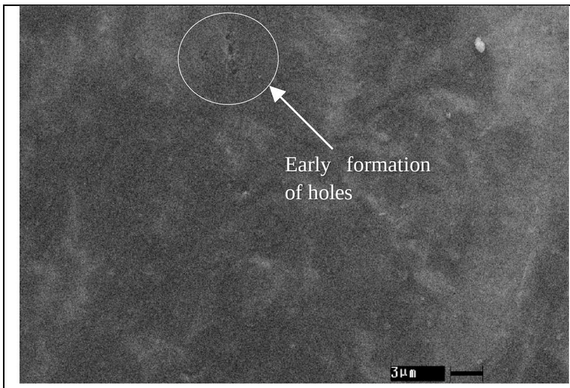
Table 4.9: Oxo-degradable Plastic Samples on Day 0 and Day 120

Sample	Day 0	Day 120
Oxo-degradable plastic sample in garden soil (S7)		
Oxo-degradable plastic sample in compost (S8)		
Oxo-degradable plastic sample in landfill soil (S9)		

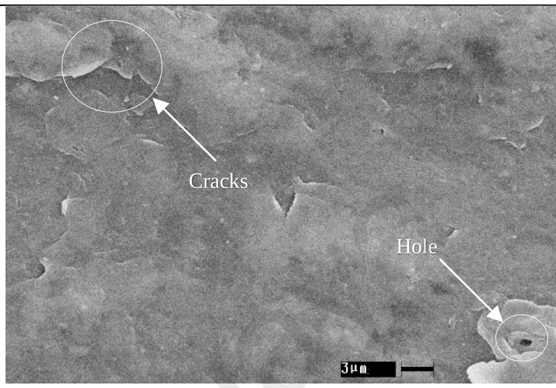
4.2.4 Surface morphology of the plastic samples under scanning electron microscope (SEM)

The surface morphology of all of the plastic samples on Day 0, Day 40, Day 80 and Day 120 intervals were carried out using SEM. On Day 0, it can be observed that the texture of non-degradable plastic sample in garden soil (S1) was rather smooth with holes starting to form as shown in Table 4.10. On Day 40 it can be observed that formation of cracks is more apparent and tiny holes were visible. On Day 80 the surface is more uneven where bigger and deeper cracks can be observed, as well as, some formation of horizontal notches.

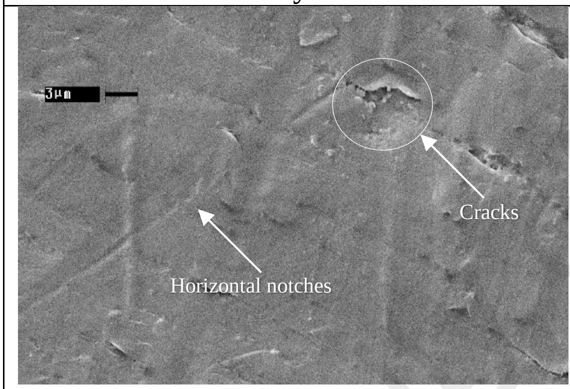
Table 4.10: Images of Non-Degradable Plastic Sample in Garden Soil (S1) Under SEM (2000 - 2300x)



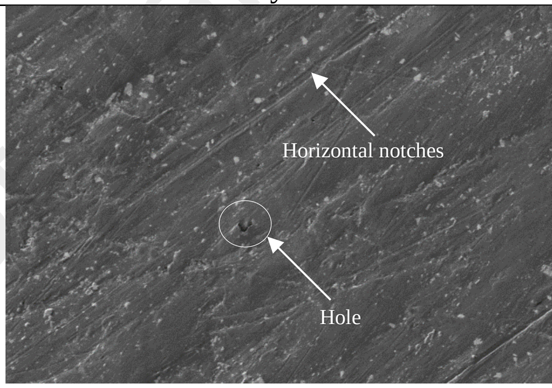
Day 0



Day 40



Day 80



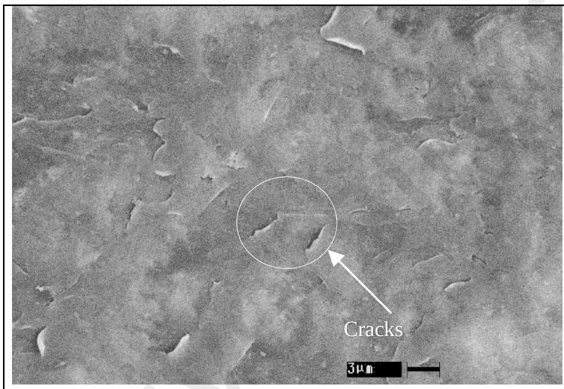
Day 120

Rougher surface, deeper cracks, holes and more horizontal notches can be observed on Day 120. Formation of cracks, holes, rough surface and horizontal notches indicates the degradation process is taking place. Cracks on the plastic surface may have caused by mechanical degradation when the plastic samples surface brushed against the burial medium. In the case of landfill soil which is the most acidic burial medium, it may contain additives such as metals that can promote degradation. Appearance of horizontal notches indicates that the surface may have come into contact with rocks or granules in the burial medium. Similar results were also observed in Cooper (2010), where plastic debris collected along the island of Kauai, Hawaii was studied. Holes or pits indicate chemical degradation took place on the sample as also observed in Corcoran et al.

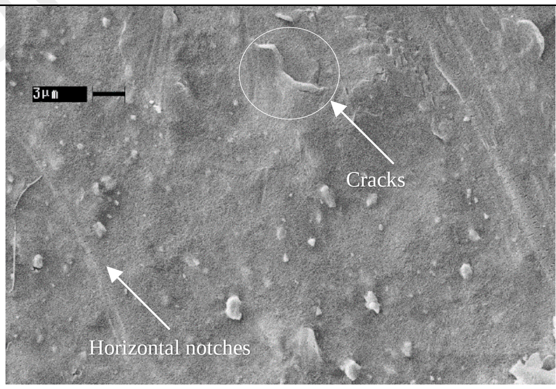
(2009) where the relationship between composition, surface textures, and plastics degradation were studied. Chemical reactions that cause the degradation perhaps were due to the burial mediums which were rather acidic.

Cracks were already observed on non-degradable plastic sample in compost (S2) on Day 0 as shown on Table 4.11. This is perhaps due to the natural texture of the plastic samples and pre-mature degradation that already taken place between production and distribution of the plastic bags. The materials are kept in either air-conditioned area or open space which makes it prone to photodegradation caused by exposure to UV light and atmospheric ozone, which occurred under normal circumstances (Cataldo et al., 2000; Singh & Sharma, 2008).

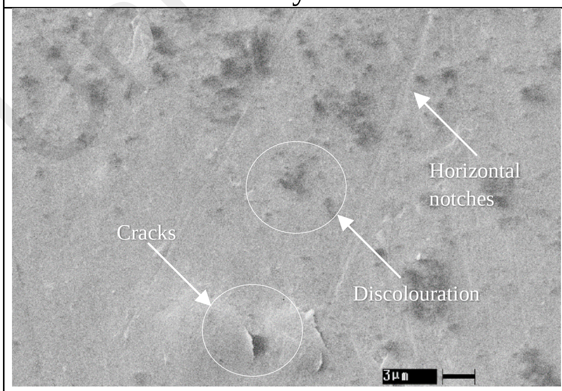
Table 4.11: Images of Non-Degradable Plastic Sample in compost (S2) Under SEM (2000-2300x)



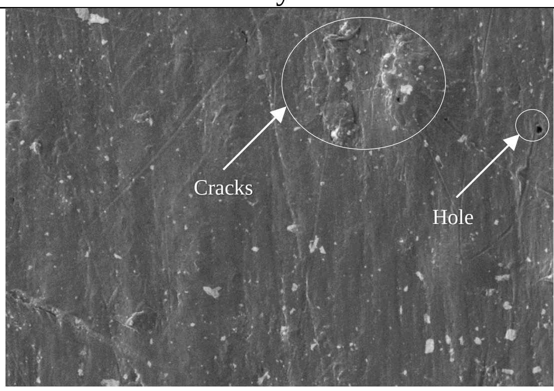
Day 0



Day 40



Day 80

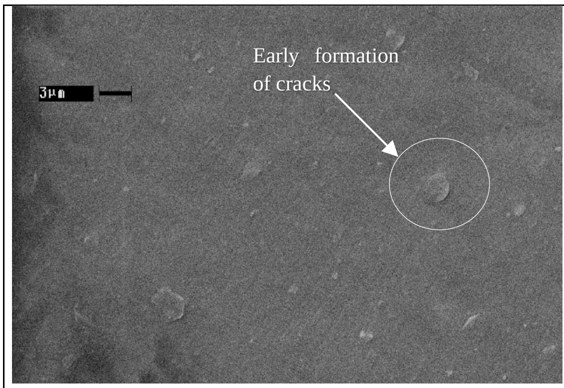


Day 120

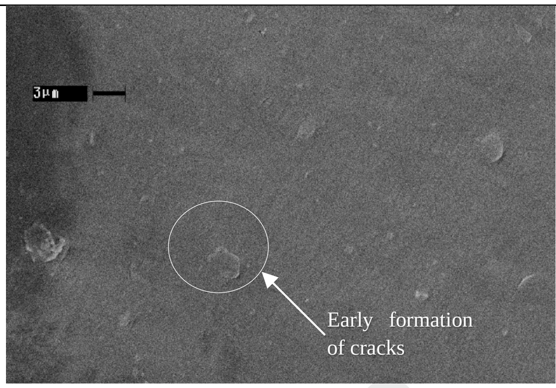
On Day 40 the surface became more uneven and rough with more cracks formation and horizontal notches. An obvious discolouration can be observed on Day 80 with rough and uneven surface, as well as, cracks and horizontal notches. On Day 120 tiny holes and more horizontal notches can be observed with rougher and more uneven texture. All of the changes observed are signs of degradation. Degradation increases with time making the degradation signs more apparent in older plastic samples. This is because exposure to environmental factors overtime will influence degradation process. Environmental factors that influence degradation are biological activity, temperature and moisture (Mostafa et al., 2010).

In Table 4.12, it can be observed that the surface for non-degradable plastic sample in landfill soil (S3) was rather smooth on Day 0 and Day 40. Early formation of cracks can be observed on Day 0 and more prominent on Day 40. Similar to non-degradable plastic sample in compost (S2), early formation of cracks indicates that degradation has already taken place on non-degradable plastic sample via photodegradation before it was buried in soil. The plastic samples were exposed to sunlight during distribution to retailers and this may have prompted the degradation to initiate due to the exposure to UV light. On Day 80 the surface appears to be uneven with horizontal notches. On Day 120 the surfaces were rougher and more uneven with discolouration and horizontal notches and these indicate the progress of degradation on the plastic sample with increased time. The discolouration observed in non-degradable plastic sample in landfill soil (S3) was perhaps due to the presence of metal in landfill soil which can act as a catalyst to promote catalytic degradation as mentioned in Singh & Sharma (2008).

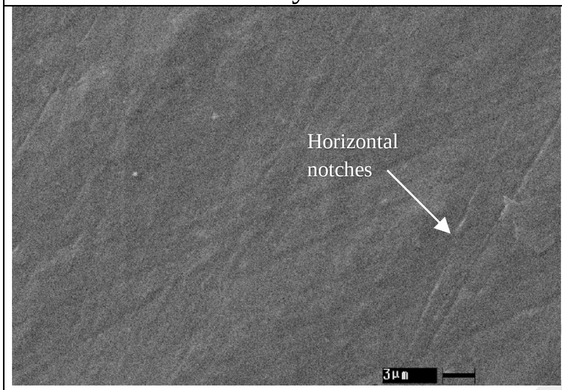
Table 4.12: Images of Non-Degradable Plastic Sample in Landfill Soil (S3) Under SEM (2000-2300x)



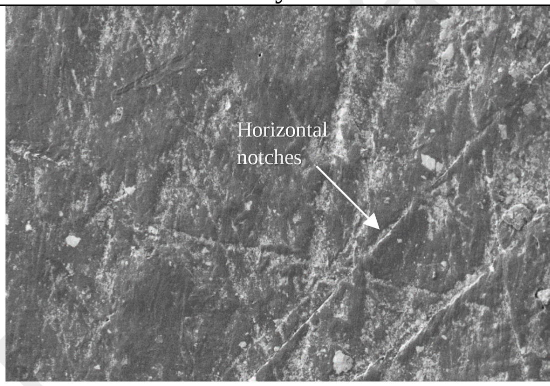
Day 0



Day 40



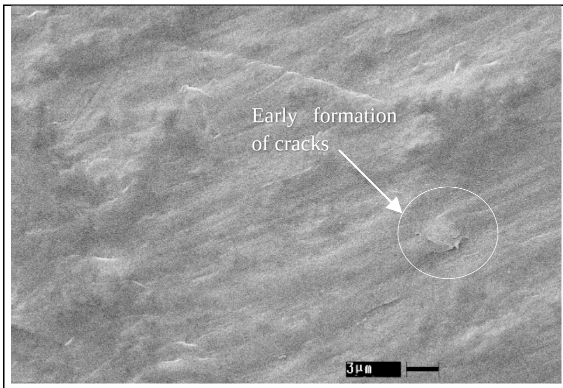
Day 80



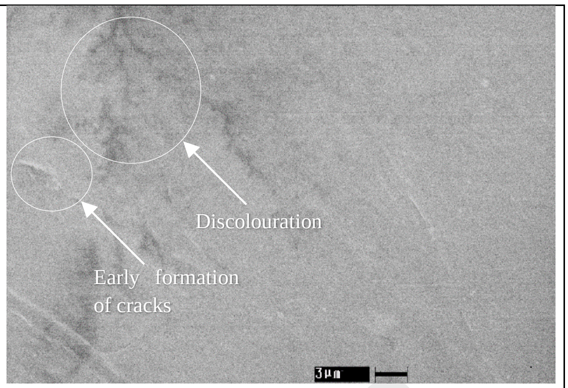
Day 120

Table 4.13 shows the surface of biodegradable plastic sample in garden soil (S4) which was already uneven on Day 0. On Day 40 discolouration and early formation of cracks can be observed. On Day 80 the surface became more uneven with a more prominent formation of crack which is due to mechanical degradation and early formation of holes and horizontal notches. Formation of holes was caused by chemical degradation within the burial medium. On Day 120 the surface became even rougher, uneven, with deeper tiny holes and crack, and horizontal notches. Degradation of biodegradable plastic sample was influenced by the presence of microorganisms in the burial medium, the presence of heat, UV, mechanical stress or water (ExcelPlas Australia, Centre for Design (RMIT University) & Nolan ITU, 2004). As time goes by more microorganisms' activity increase the degradation of the plastic samples.

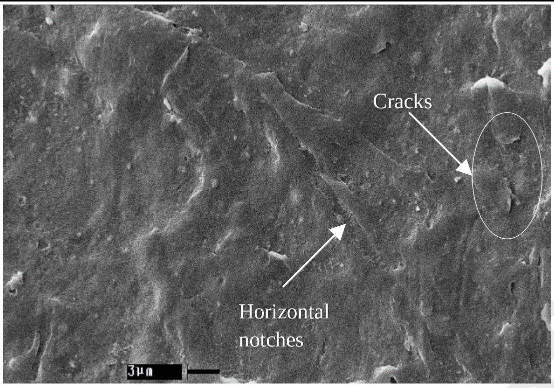
Table 4.13: Images of Biodegradable Plastic Sample in Garden Soil (S4) Under SEM (2000-2300x)



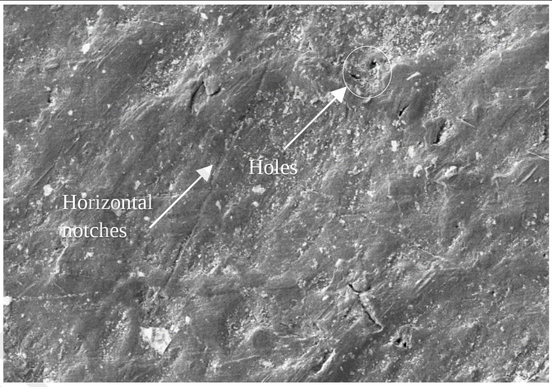
Day 0



Day 40



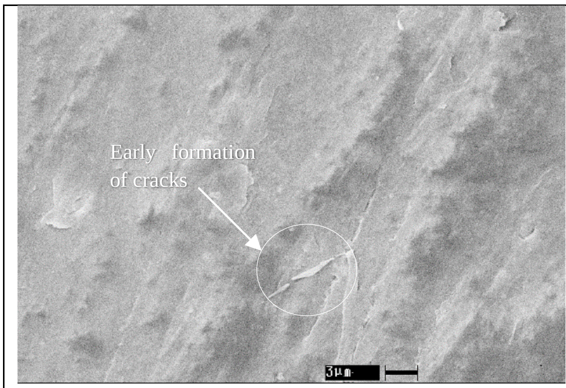
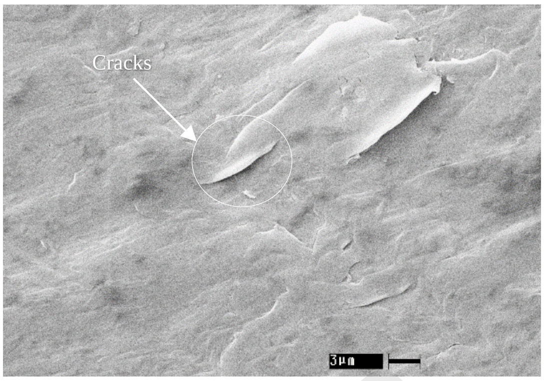
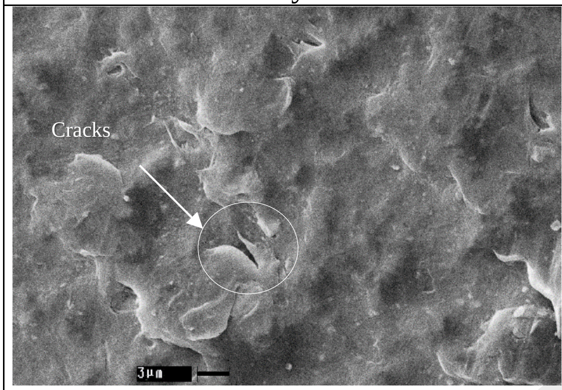
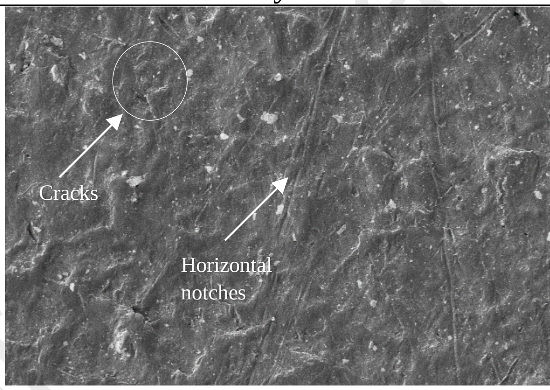
Day 80



Day 120

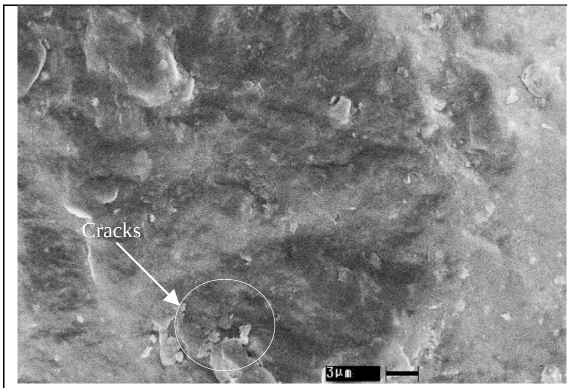
Uneven surface and early formation of crack can already be observed on biodegradable plastic sample in compost (S5) on Day 0 as seen in Table 4.14. The early formation of cracks is perhaps due to the pre-mature degradation that already takes place between production and distribution of the plastic bags. This is because the plastic materials were exposed to sunlight that prompted photodegradation to happen (Cataldo et al., 2000; Singh & Sharma, 2008). Due to this, the signs of degradation on Day 0 will not be taken into account as part of the research's results. A bigger crack can be observed on Day 40. On Day 80 the surface showed more formation crack and rougher surface. The plastic surface was rougher and more uneven on Day 120 with horizontal notches and cracks, indicating a sign of increased degradation over time of exposure.

Table 4.14: Images of Biodegradable Plastic Sample in Compost (S5) Under SEM (2000-2300x)

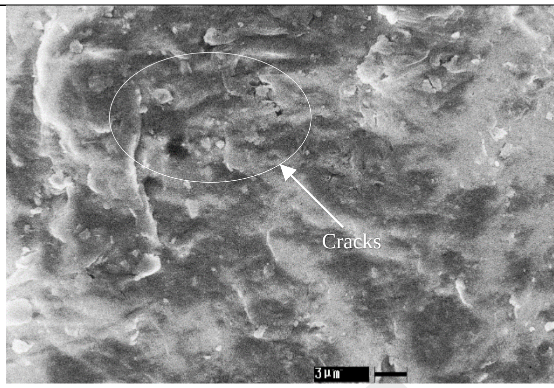
	
Day 0	Day 40
	
Day 80	Day 120

On Day 0, biodegradable plastic sample in landfill soil (S6) showed uneven surface and formation of cracks (Table 4.15). This is caused by photodegradation due to the exposure to sunlight before the plastic samples were buried. Again, the observation on Day 0 will not be taken into consideration as the results of this study. The surface appeared to be more uneven with early formation of tiny holes and more prominent cracks. On Day 80 a few bigger cracks and horizontal notches can be observed on biodegradable plastic sample in landfill soil (S6). On Day 120 the surface appears to be rougher and more uneven, where more horizontal notches and deep tiny holes can be observed. As exposure time prolonged more degradation took place in the plastic samples that increases the formation of cracks, holes and horizontal notches.

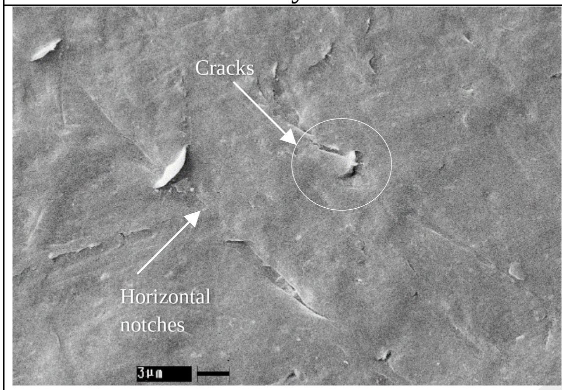
Table 4.15: Images of Biodegradable Plastic Sample in Landfill Soil (S6) Under SEM (2000-2300x)



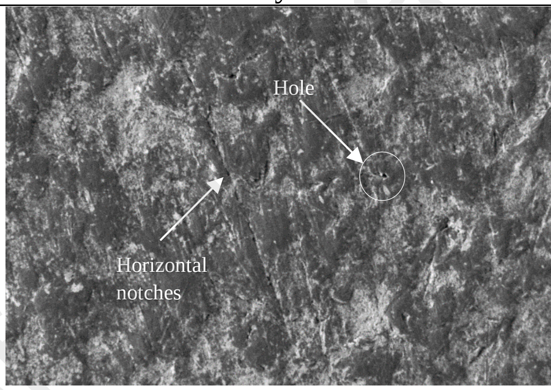
Day 0



Day 40



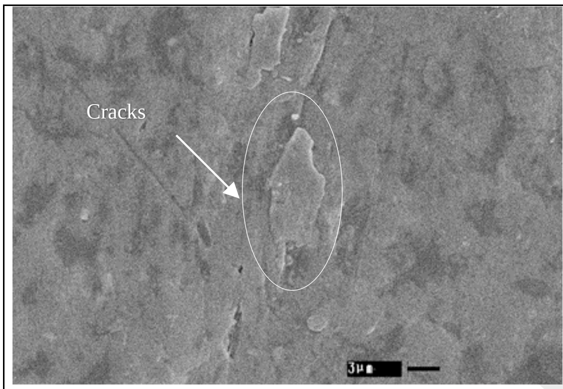
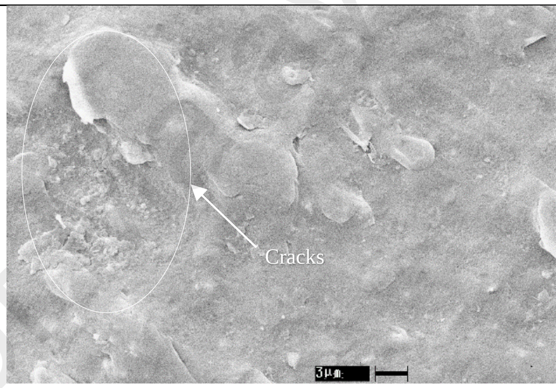
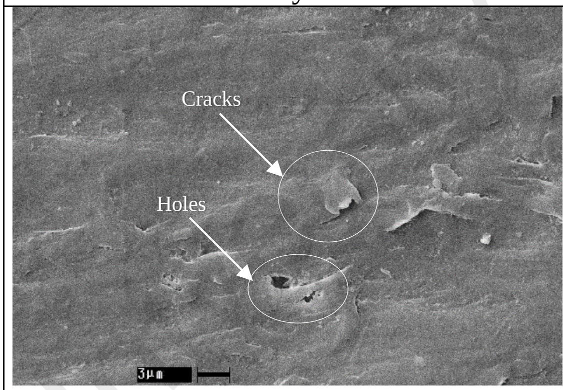
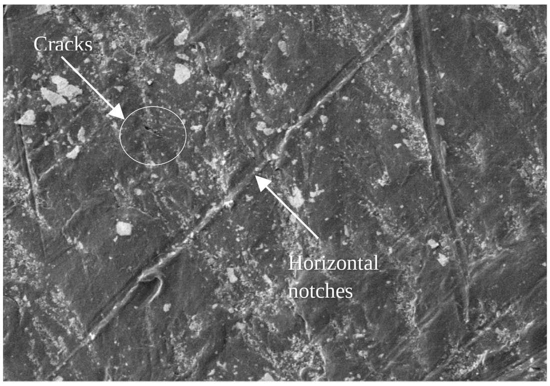
Day 80



Day 120

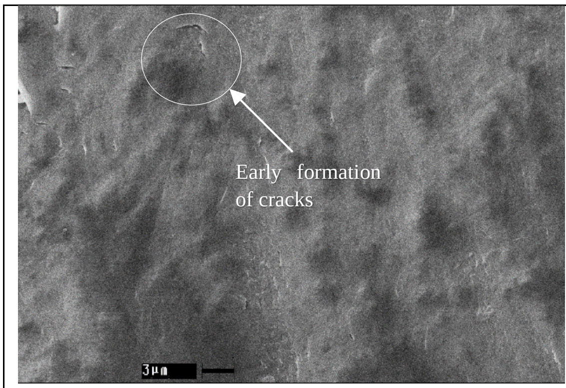
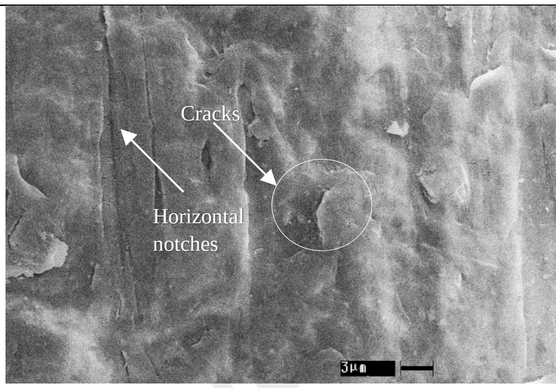
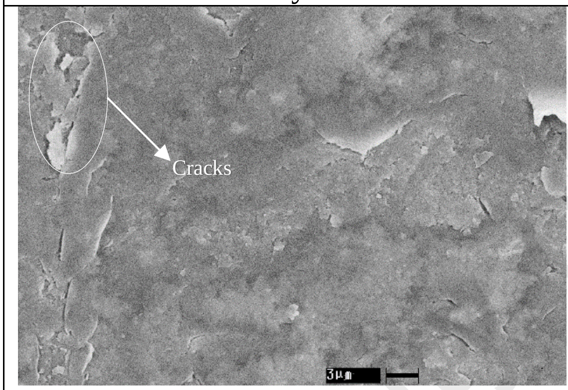
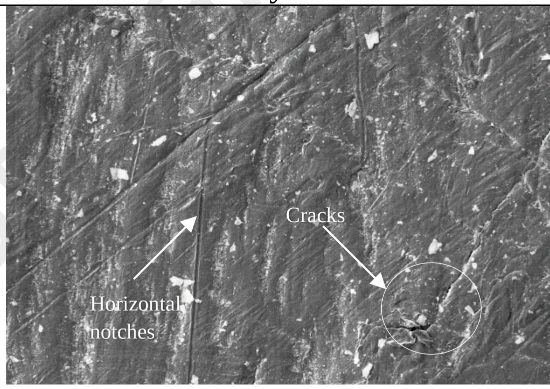
Table 4.16 shows oxo-degradable plastic sample in garden soil (S7) which has already shown formation of cracks on Day 0. This is due to pre-mature degradation caused by the exposure to sunlight under normal atmospheric and weather conditions (Singh & Sharma, 2008). The presence of UV light and atmospheric ozone promotes oxidative degradation where the long chains of polyethylene molecules in the oxo-degradable plastic samples are broken down into shorter lengths by the action of oxygen, UV light and/or heat (Thomas et al., 2010). This probably had happened before the plastic samples were buried in the burial medium. Hence, the observation on Day 0 is not going to be taken as the results of the soil burial test. On Day 40 bigger cracks can be observed on the surface of oxo-degradable plastic sample in garden soil (S7). On Day 80 more prominent cracks and a hole can be observed. On Day 120 the surface of oxo-degradable plastic sample in garden soil (S7) appears to be rougher and more uneven with clear appearance of a couple of horizontal notches. All of the observation indicates degradation process has taken place in the plastic samples. Degradation of oxo-degradable plastic sample throughout the soil burial test is caused by biodegradation. Biodegradation in oxo-degradable plastic sample is caused by microorganism activities in the burial medium (Thomas et al., 2010). The oxidative degradation that happens with the presence of sunlight earlier has provided the pathway for biodegradation to happen in the soil burial test.

Table 4.16: Images of Oxo-Degradable Plastic Sample in Garden Soil (S7) Under SEM (2000-2300x)

 Day 0	 Day 40
 Day 80	 Day 120

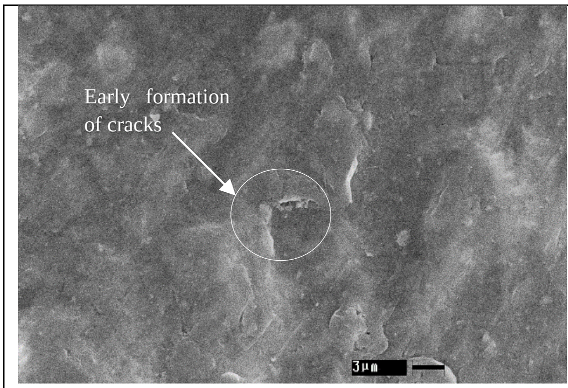
It can be observed in Table 4.17 that cracks are starting to form on oxo-degradable plastic sample in compost (S8) surface on Day 0. Again, this is a sign of pre-mature degradation that has taken place before the plastic sample was tested. On Day 40 and Day 80, more apparent formation of cracks, as well as, horizontal notches can be observed. On Day 120, the surface appears to be more uneven and rougher with appearance of holes and horizontal notches. This is due to degradation caused by the presence of additive in the plastic sample, and the presence of sunlight and heat in the environment.

Table 4.17: Images of Oxo-Degradable Plastic Sample in Compost (S8) Under SEM (2000-2300x)

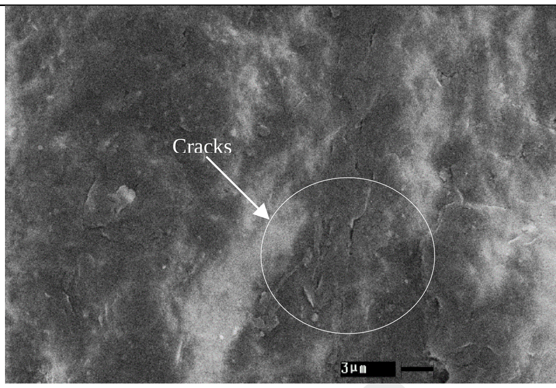
 Day 0	 Day 40
 Day 80	 Day 120

The surface of oxo-degradable plastic sample in landfill soil (S9) was rather smooth on Day 0 and Day 40 with early formation of cracks can be observed in Table 4.18. On Day 80, early formation of horizontal notches can be observed, yet the cracks were not that apparent. On Day 120, the surface appears to be more uneven and rougher with clear formation of cracks, horizontal notches and some tiny holes. The formation of cracks, horizontal notches and some tiny holes indicate degradation process on the plastic sample due to environmental factor such as sunlight and heat, as well as, the presence of additives in the plastic sample.

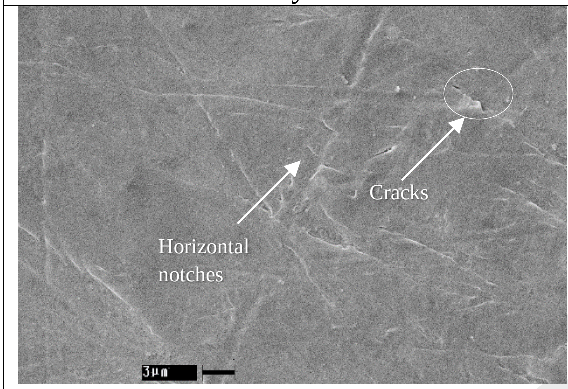
Table 4.18: Images of Oxo-Degradable Plastic Sample in Landfill Soil (S9) Under SEM (2000-2300x)



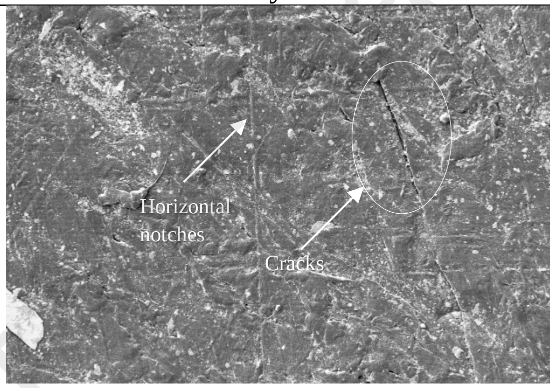
Day 0



Day 40



Day 80



Day 120

In all of nine (9) of the plastic samples, signs of degradation such as the appearance of cracks, hole and horizontal notches increased and became more apparent as time goes by. These morphological changes are consistent with the weight loss observed in all of the materials earlier. The longer the burial period the more degradation signs can be observed.

Although the degradation took place in all of the plastic samples, the factor that causes degradation to happen in different plastic samples may differ. The changes observed in non-degradable plastic samples are due to mechanical degradation and microorganisms activities. Similar observation was also recorded by Campos et al. (2012) in polyvinyl chloride (PVC) plastic samples. Non-degradable plastic samples are usually more resistant to chemical changes due to its physical and chemical properties (Koutny et al., 2006). Nonetheless, fungi were found to be able to easily attach to polymer surface due to its ability to form hydrophobic proteins (Sahebnazar et al., 2010). This allows biodegradation to happen in non-degradable plastic sample in the presence of microorganism, such as fungi. Non-degradable plastic samples in garden soil and compost showed more obvious formation of cracks, holes and horizontal notches, this is perhaps due to the pH of both mediums which are closer to the ideal pH for microorganism activities. This is also consistent with the weight loss comparisons where plastic samples for non-degradable plastic samples in garden soil and compost showed the highest weight loss after 120 days.

Biodegradable plastic sample in landfill soil showed the most obvious morphological changes since Day 0 as compared to biodegradable samples in garden soil and compost. This is perhaps due to catalytic degradation which can happen in the presence of metals in landfill soil (Singh & Sharma, 2008). Although Campos et al. (2012) reported that the presence of leachate in landfill soil deteriorates the biodegradation of plastic samples. Perhaps the presence of metal in landfill soil contributed most to the degradation process in biodegradable plastic sample. The results also consistent with the weight loss recorded where biodegradable plastic sample in landfill soil recorded the highest weight loss as compared to the biodegradable plastic samples in garden soil and compost.

In oxo-degradable plastic sample, the plastic sample in garden soil showed the most obvious morphological changes throughout the burial period. A clear formation of hole was also seen in Day 80 for oxo-degradable plastic sample in garden soil which is not seen in other oxo-degradable plastic samples. Even on Day 0 a clear formation of cracks can be seen on oxo-degradable plastic sample in garden soil. This is an indication that photodegradation has taken place before the soil burial test due to UV exposure and heat. The pre-mature degradation provide pathway for biodegradation to happen during the soil burial test in the presence of microorganisms activity. Garden soil with average pH between pH 5.18 and pH 5.20 is close to the ideal pH for microorganism activity. Even though, compost possess an ideal pH for microorganism activity between pH 6.78 and pH 6.86, the morphological changes on the oxo-degradable plastic sample on Day 0 was not as apparent as on oxo-degradable plastic sample in garden soil. Perhaps, oxo-degradable plastic sample in garden soil has went through a longer and more intense photodegration that makes it more prone to biodegradation which can only take place after oxo-degradable plastic sample degrade (Thomas et al., 2010)

4.2.5 Characterization of chemical changes in plastic samples by Fourier Transform Infra-Red (FTIR) spectroscopy

In the study of the degradation of plastic samples, FTIR was used to compare the alteration in functional groups of each plastic sample before and after the burial in the three (3) different mediums; garden soil, compost and landfill soil.

Infrared spectrums comparing the non-degradable plastic samples before and after burial in garden soil are shown in Figure 4.3, Figure 4.4 and Figure 4.5. After 40 days of burial in garden soil (Figure 4.3) there was no new formation of neither carbonyl nor vinyl group observed on the spectrum for the non-degradable plastic sample in garden soil (S1). The only observation recorded was the slight increase in intensities for peak 2852.85 cm^{-1} and 1460.98 cm^{-1}. The changes on peak 2852.85 cm^{-1} indicate the C-H bond which is presence in most organic compounds. This indicates that there are no chemical changes in the plastic samples due to degradation.

After 80 and 120 days of burial in garden soil, a few new absorbances were observed on the fingerprint region at 874.85 cm^{-1} and 527.01 cm^{-1}. Fingerprint region are usually caused by intra-molecular phenomena such as molecular vibrations, and usually involves bending motions ("Infrared spectroscopy," 1997). The fingerprint region consists of a complicated series of bands that may overlap each other hence making it hard to identify individual bands and assign them to a particular functional group (Bridgeman, 2013). Hence, peaks in the fingerprint region where absorption bands falls between 500 cm^{-1} to 1500 cm^{-1} are not an accurate indicator of degradation.

The intensities improved as the burial period increased. The peaks showed slight improvement in their intensities on Day 80 at peak 2918.81 cm^{-1} and 1460.98 cm^{-1}. However, the peaks at, 2852.85 cm^{-1}, 874.85 cm^{-1}, 721.91 cm^{-1}, and 527.01 cm^{-1} showed a slight decrease in intensities. This is perhaps due to lower of energy levels in the plastic molecules as discussed in "How an FTIR Spectrometer operates" (n.d.). All of the peaks showed the most significant increase in intensities on Day 120 which is probably the results of the lower molecular fragments caused by the degradation of the plastic samples. These results are consistent with the weight loss observed in non-degradable plastic sample in garden soil (S1) earlier. Similar observation was also seen in Suhaila (2007), where only slight changes in the existing peaks were observed but there were no signs of new carbonyl group formation in the spectrum.

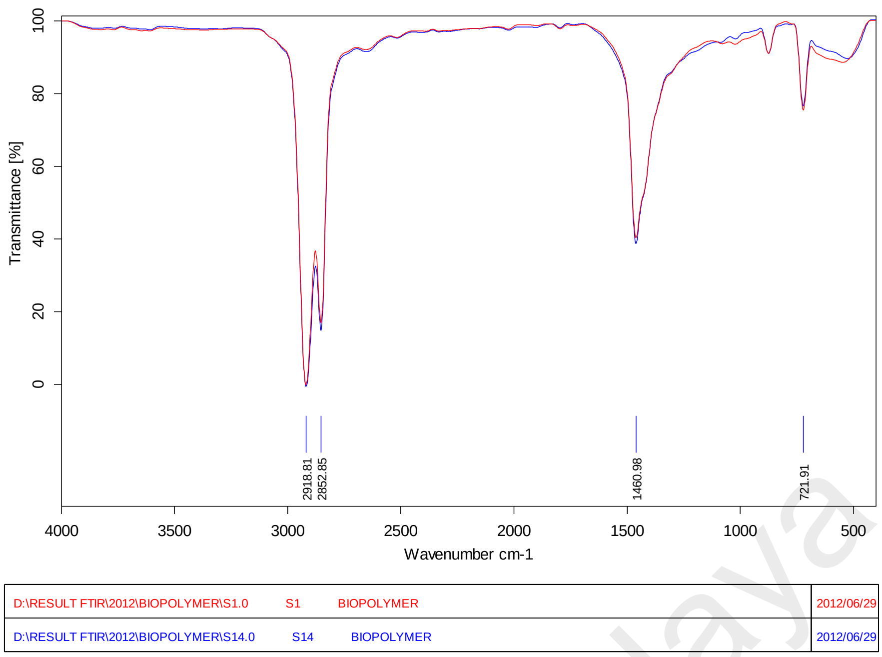


Figure 4.3: Comparison of FTIR Spectra of Non-Degradable Plastic Sample Before and After Incubation in Garden Soil (S1) for 40 Days

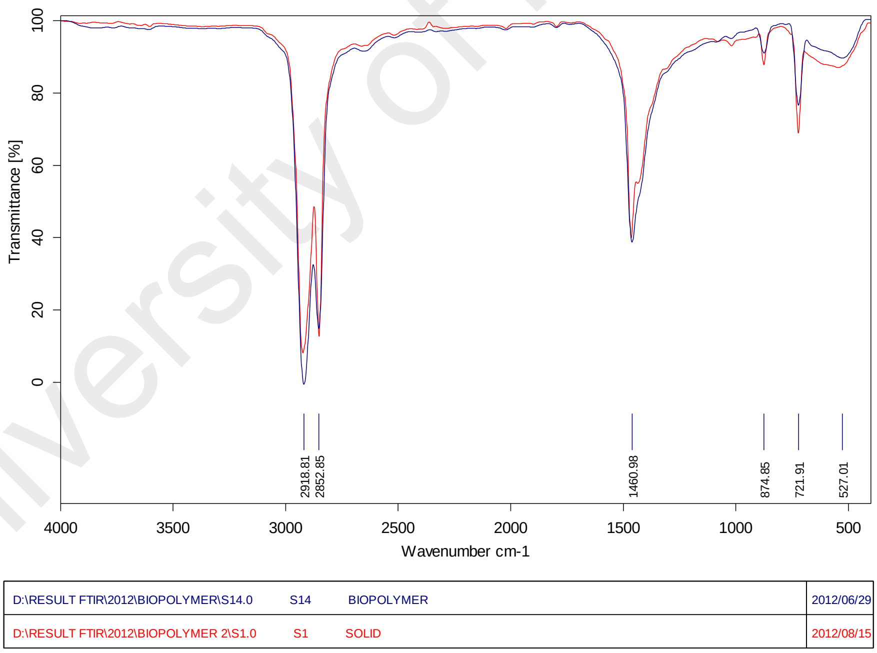


Figure 4.4: Comparison of FTIR Spectra of Non-Degradable Plastic Sample Before and After Incubation in Garden Soil (S1) for 80 Days

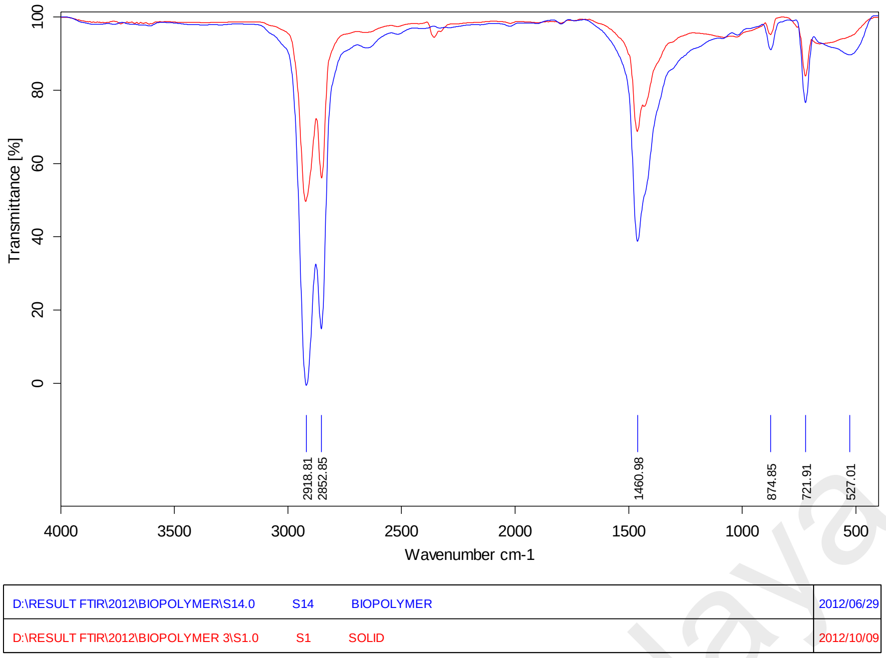


Figure 4.5: Comparison of FTIR Spectra of Non-Degradable Plastic Sample Before and After Incubation in Garden Soil (S1) for 120 Days

Figure 4.6, Figure 4.7 and Figure 4.8 show infrared spectrums of non-degradable plastic bag before and after burial in compost. Figure 4.6 shows that there are no new absorbance on the spectrum for the non-degradable plastic sample in compost (S2) except for a slight increase in intensities for peak 1460.89 cm^{-1} and slight decrease in intensity for peak 721.69 cm^{-1}. After 80 and 120 days a few new absorbance were observed on the fingerprint region at 874.85 cm^{-1} and 527.01 cm^{-1}. The intensities improved as the burial period increased. This is a sign of biodegradation due to the increase in microorganism activities in compost. As discussed earlier, compost has the most ideal pH for microorganisms' activity which is between pH 6.78 and pH 6.86. The peaks showed an improvement in their intensities on Day 80 at peak 2918.81 cm^{-1}, 2852.85 cm^{-1} and 1460.98 cm^{-1}. However, the peak at 874.85 cm^{-1} showed a slight decrease in intensities and no changes in intensity on peak 721.91 cm^{-1}. On Day 120 the intensities decreased for peak 2918.81 cm^{-1}, 2852.85 cm^{-1} and 1460.98 cm^{-1}, and increase for peak 874.85 cm^{-1}, 721.91 cm^{-1} and 527.01 cm^{-1}. The peaks intensity increased on Day 120 are consistent with the weight loss results which probably is the resultant of the lower molecular fragments caused by the degradation of the plastic samples. As for the peaks intensity decreased perhaps due to the decrease in the presence of those bonds because of the utilization of oxidised polymers by the microorganisms as discussed in Arutchelvi et al. (2008).

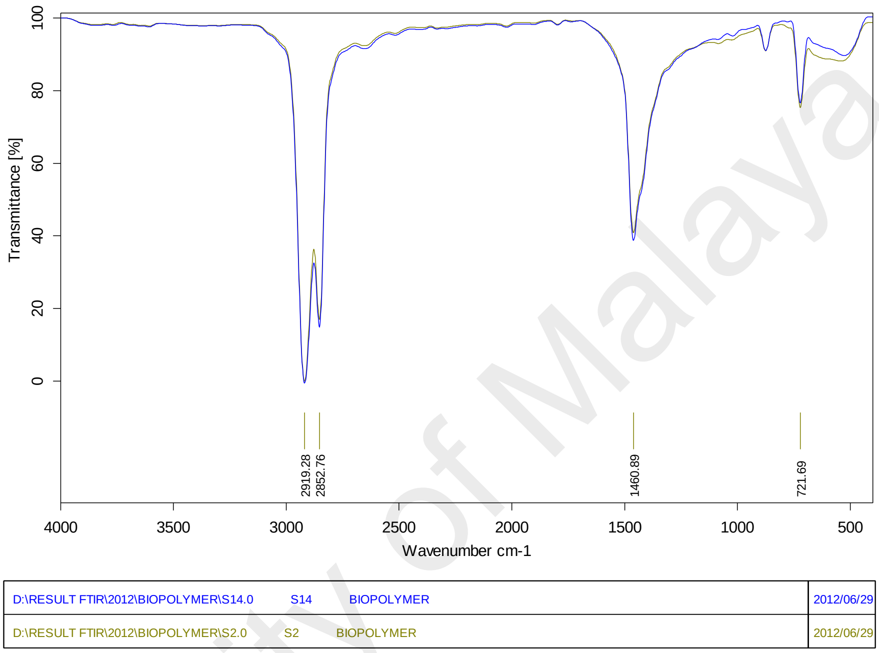


Figure 4.6: Comparison of FTIR Spectra of Non-Degradable Plastic Sample Before and After Incubation in Compost (S2) for 40 Days

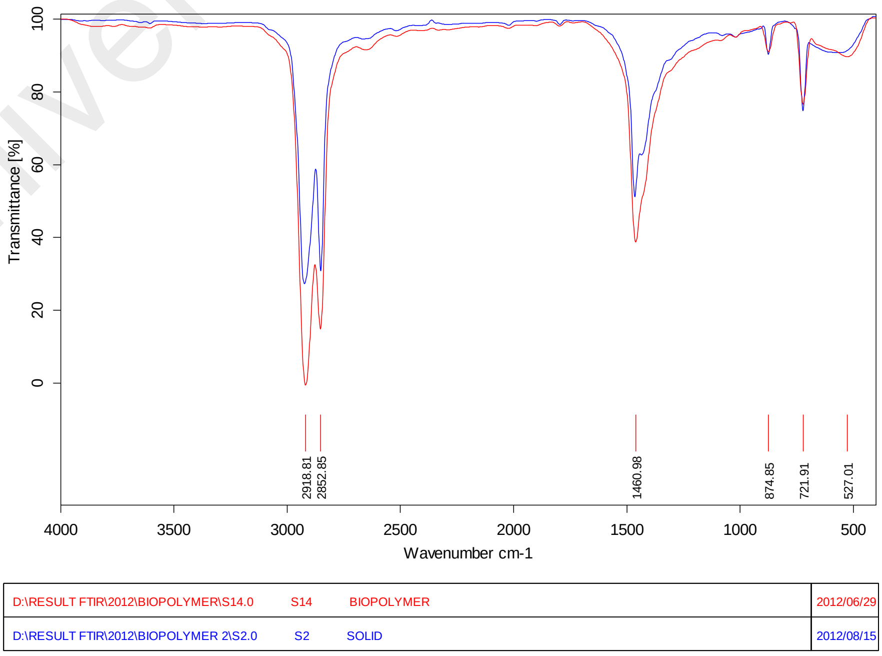


Figure 4.7: Comparison of FTIR Spectra of Non-Degradable Plastic Sample Before and After Incubation in Compost (S2) for 80 Days

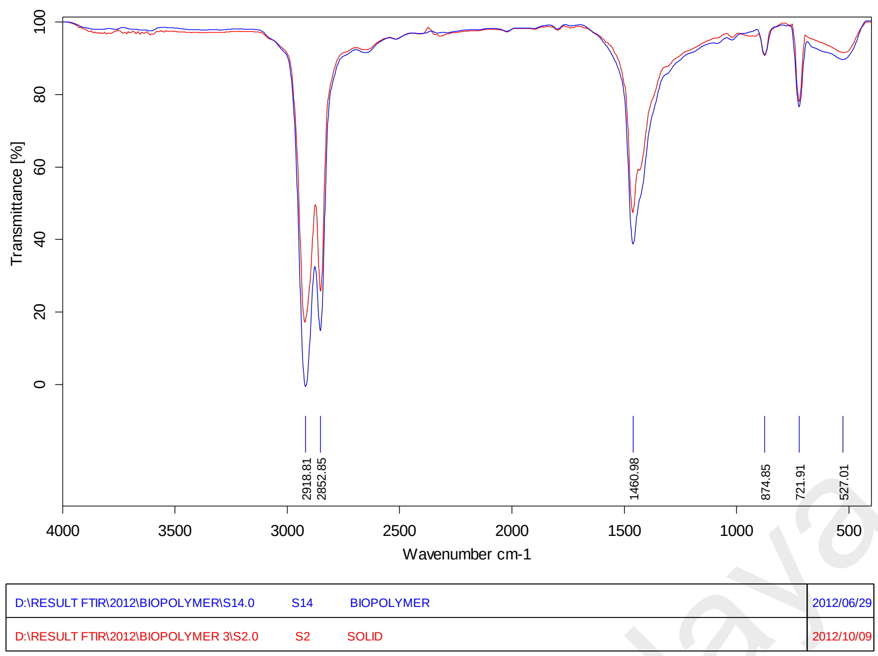


Figure 4.8: Comparison of FTIR Spectra of Non-Degradable Plastic Sample Before and After Incubation in Compost (S2) for 120 Days

Figure 4.9, Figure 4.10 and Figure 4.11 show infrared spectrums of non-degradable plastic bag before and after burial in landfill soil. After 40 days of burial in landfill soil (Figure 4.9) there are no new peak observe on the spectrum for the non-degradable plastic sample in landfill soil (S3) except for a slight increase in intensity for peak 1461.43 cm^{-1}. After 80 and 120 days of burial in landfill soil, a few new absorbances were observed on the spectrum at 874.85 cm^{-1} and 527.01 cm^{-1}. All of the peaks showed improvement in their intensities on Day 80. However, the intensities decreased on Day 120. Although, non-degradable plastic sample in landfill soil (S3) recorded weight loss of 7.5%, the decrease in intensities on Day 120 perhaps is because most of the weight loss happened between Day 0 and Day 80. It could also means the decrease in presence of those bonds due to the utilization of oxidised polymers by the microorganisms.

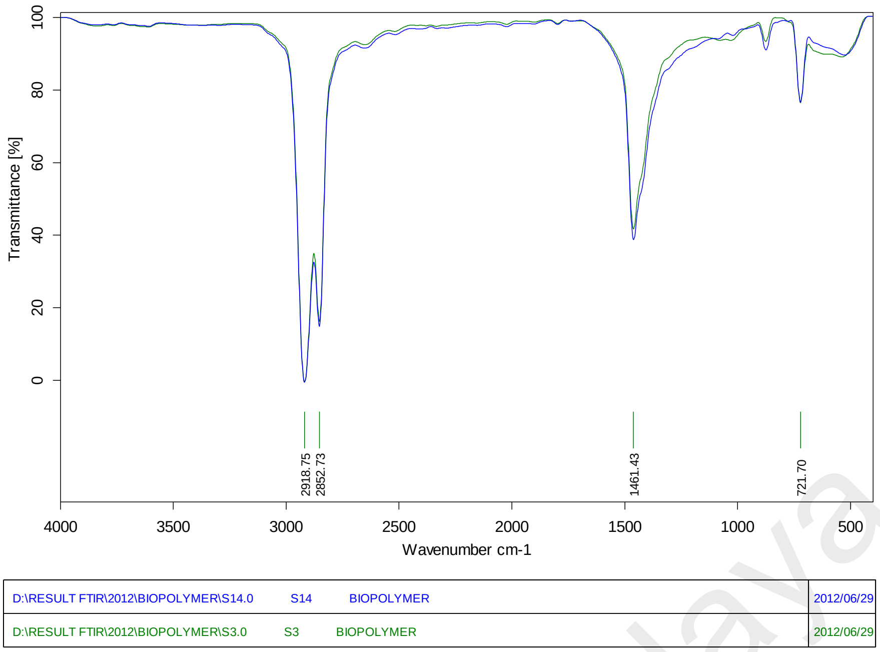


Figure 4.9: Comparison of FTIR Spectra of Non-Degradable Plastic Sample Before and After Incubation in Landfill Soil (S3) for 40 Days

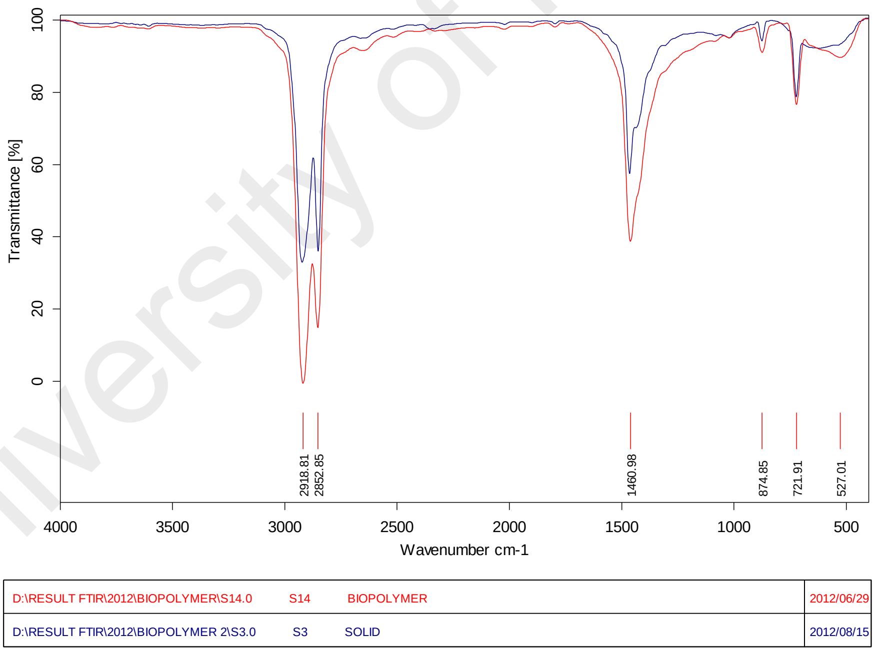


Figure 4.10: Comparison of FTIR Spectra of Non-Degradable Plastic Sample Before and After Incubation in Landfill Soil (S3) for 80 Days

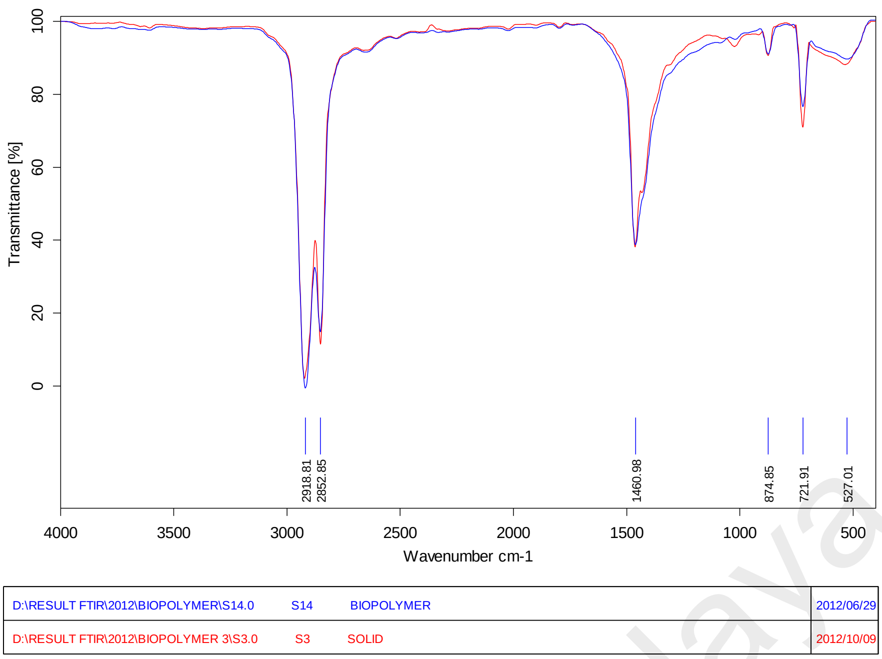


Figure 4.11: Comparison of FTIR Spectra of Non-Degradable Plastic Sample Before and After Incubation in Landfill Soil (S3) for 120 Days

Figure 4.12, Figure 4.13 and Figure 4.14 show infrared spectrums of biodegradable plastic bag before and after burial in garden soil (S4). After 40 days of burial in garden soil (Figure 4.12) it was observed that there were increase intensity in the following peaks 2852.13 cm^{-1}, 1797.30 cm^{-1}, 1457.37 cm^{-1}, 875.53 cm^{-1} and 721.85 cm^{-1}. Most of the peaks' intensities improved on Day 80 except for 876.39 cm^{-1}. All of the peaks' intensities continue to improve as observed on Day 120. This is probably the results of the lower molecular fragments caused by the degradation of the plastic samples. These results are consistent with the weight loss observed in biodegradable plastic sample in garden soil (S4) earlier. There was no new absorbance observed throughout the whole 120 days of burial. Suhaila (2007) observed similar trends in the increase of peak intensities for its plastic samples containing 30% of starch. Similarly in Shujun et al. (2006), it was observed that the peak intensities increase with time in plastic samples containing corn starch.

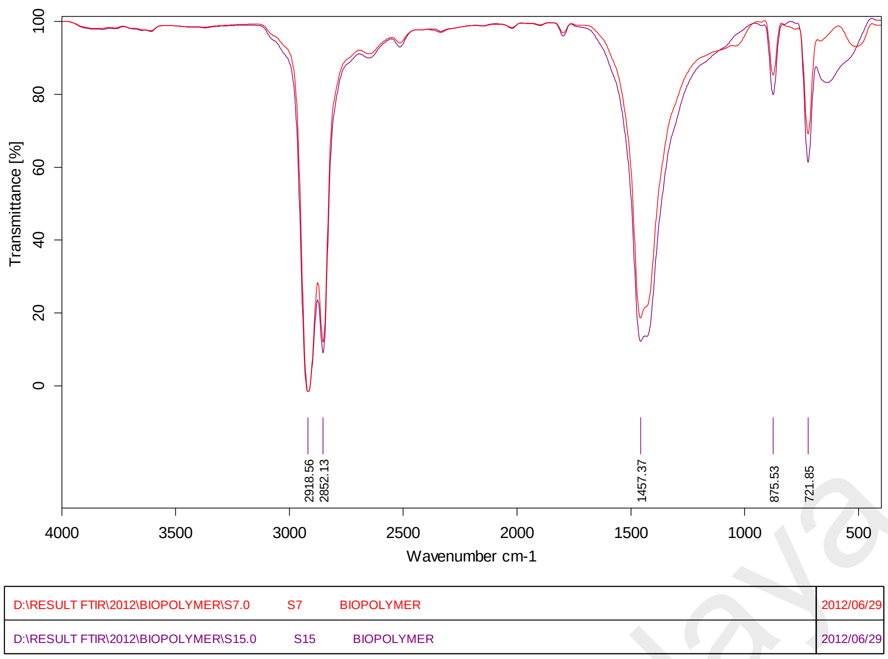


Figure 4.12: Comparison of FTIR Spectra of Biodegradable Plastic Sample Before and After Incubation in Garden Soil (S4) for 40 Days

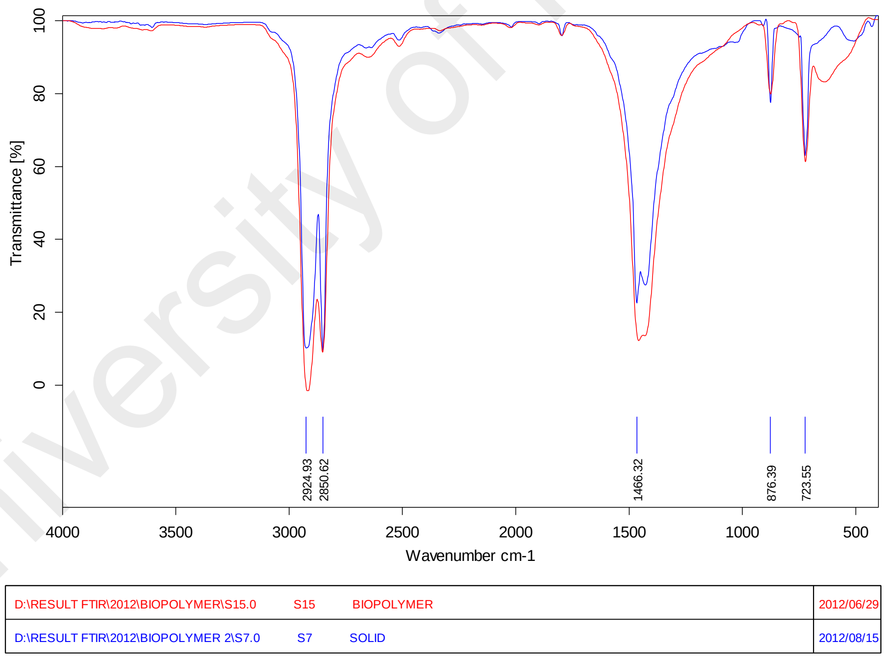


Figure 4.13: Comparison of FTIR Spectra of Biodegradable Plastic Sample Before and After Incubation in Garden Soil (S4) for 80 Days

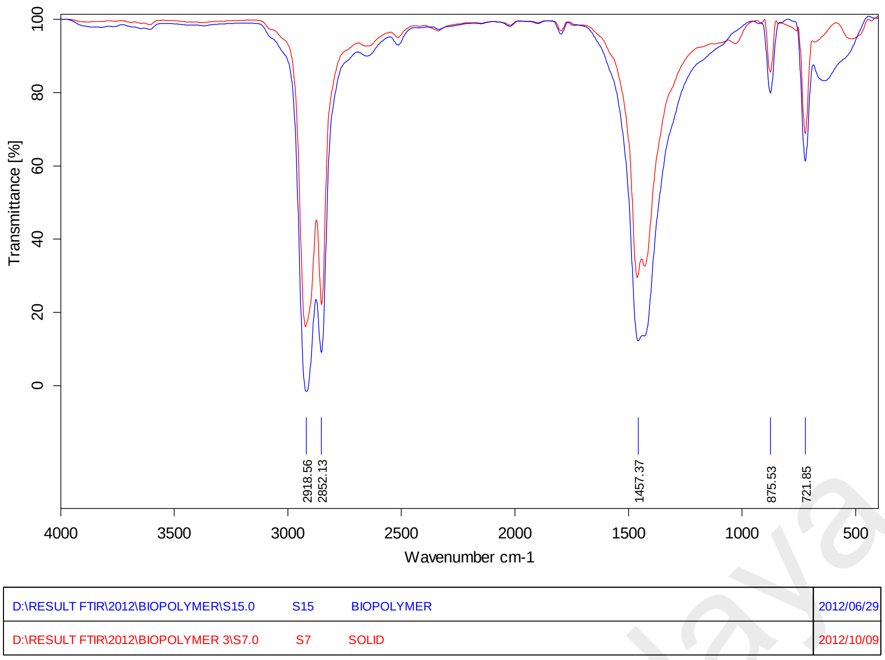


Figure 4.14: Comparison of FTIR Spectra of Biodegradable Plastic Sample Before and After Incubation in Garden Soil (S4) for 120 Days

Figure 4.15, Figure 4.16 and Figure 4.17 show infrared spectrums of biodegradable plastic bag before and after burial in compost (S5). After 40 days of burial in compost (Figure 4.15) it was observed that there were increase in intensities for the following peaks 2852.11 cm^{-1}, 1797.30 cm^{-1}, 1458.41 cm^{-1} and 721.86 cm^{-1}. This indicates starch degradation took place in the plastic sample. Similar observation was also reported in Shujun et al. (2006) in plastic samples containing corn starch. After 80 and 120 days of burial in compost, a new absorbance was observed on the spectrum at 719.43 cm^{-1}. However, this does not indicate specific changes in functional group in the plastic because it falls under the fingerprint region where intra-molecular phenomena occur. The intensities improved as the burial period increased. The peaks showed improvements in their intensities on Day 80 for most of the peaks except for 876.09 cm^{-1} where the intensities decreased. This is perhaps due to loss of absorption due to the removal of starch components after degradation which was also observed in the plastic samples containing starch (Suhaila, 2007). The most significant increase in intensities was observed on Day 120 on all peaks. This is probably the results of the lower molecular fragments caused by the degradation of the plastic samples. These results are consistent with the weight loss observed in biodegradable plastic sample in compost (S5).

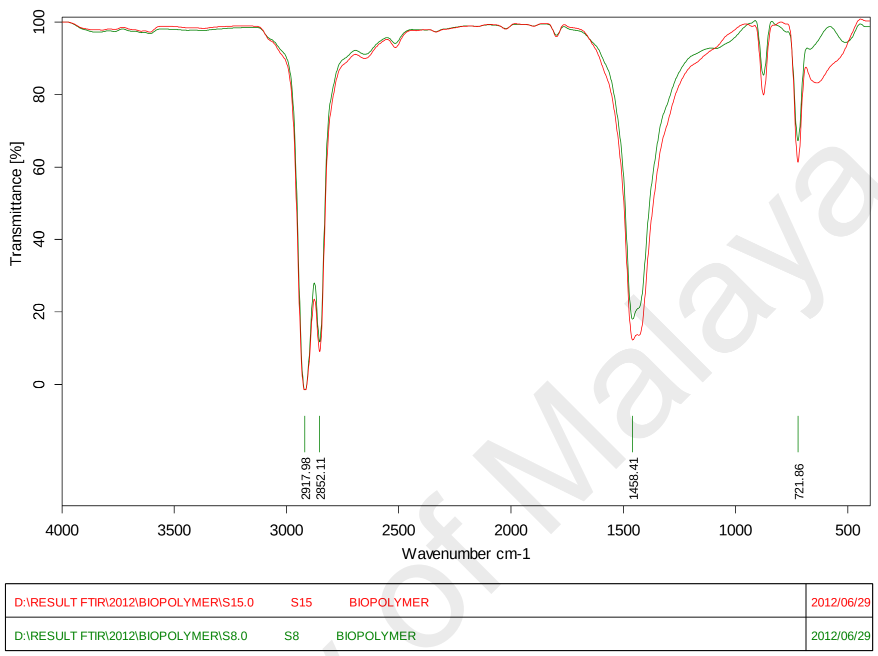


Figure 4.15: Comparison of FTIR Spectra of Biodegradable Plastic Sample Before and After Incubation in Compost (S5) for 40 Days

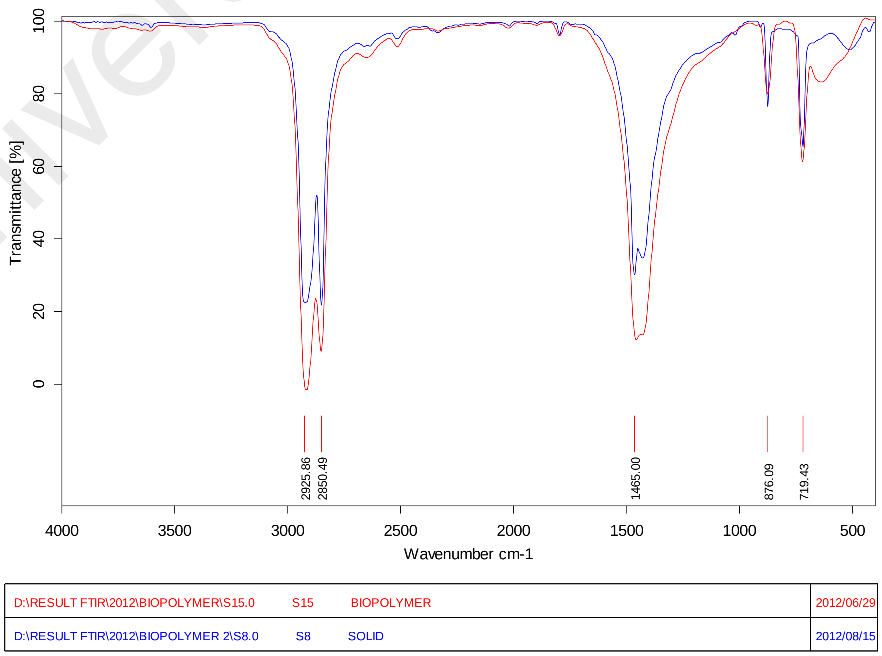


Figure 4.16: Comparison of FTIR Spectra of Biodegradable Plastic Sample Before and After Incubation in Compost (S5) for 80 Days

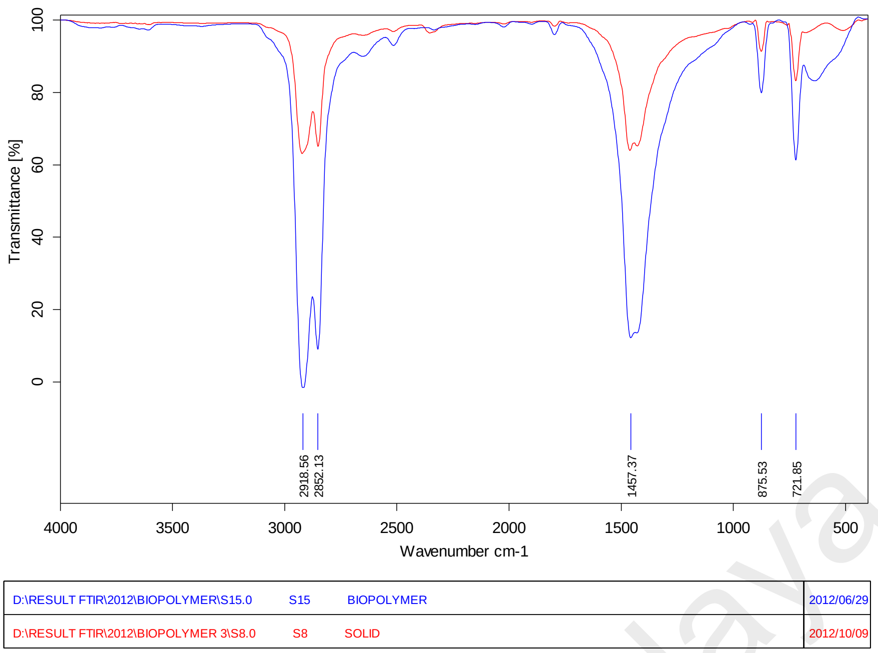


Figure 4.17: Comparison of FTIR Spectra of Biodegradable Plastic Sample Before and After Incubation in Compost (S5) for 120 Days

Figure 4.18, Figure 4.19 and Figure 4.20 show infrared spectrums of biodegradable plastic bag before and after burial in landfill soil (S6). After 40 days of burial in landfill soil the 2851.81 cm^{-1}, 1797.30 cm^{-1}, 1458.14 cm^{-1} and 721.85 cm^{-1} peaks show increase in intensities (Figure 4.18). After 80 days of burial the 2917.56 cm^{-1}, 1797.30 cm^{-1} and 1463.45 cm^{-1} peaks also show increase in intensities. The rest of the peaks (2850.19 cm^{-1},875.99 cm^{-1} and 718.81 cm^{-1}) decreases in its intensities on Day 80. The increase of peaks' intensities indicates starch degradation in the biodegradable plastic samples. The decrease in intensities was perhaps due to the removal of starch component from the plastic sample. Similar observation was reported by Suhaila (2007), where plastic samples containing starch recorded increase in peak intensities, as well as, decrease in intensity at peak 979 cm^{-1}. After 120 days, the intensities for all of the peaks improved significantly. This is probably the results of the lower molecular fragments caused by the degradation of the plastic samples. These results are consistent with the weight loss observed in biodegradable plastic sample in landfill soil (S6) earlier.

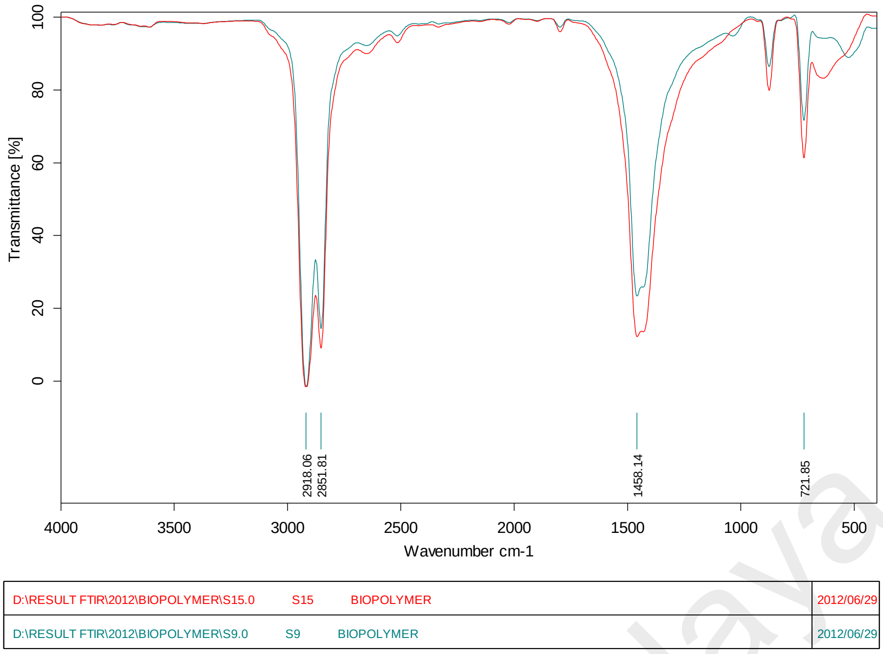


Figure 4.18: Comparison of FTIR Spectra of Biodegradable Plastic Sample Before and After Incubation in Landfill Soil (S6) for 40 Days

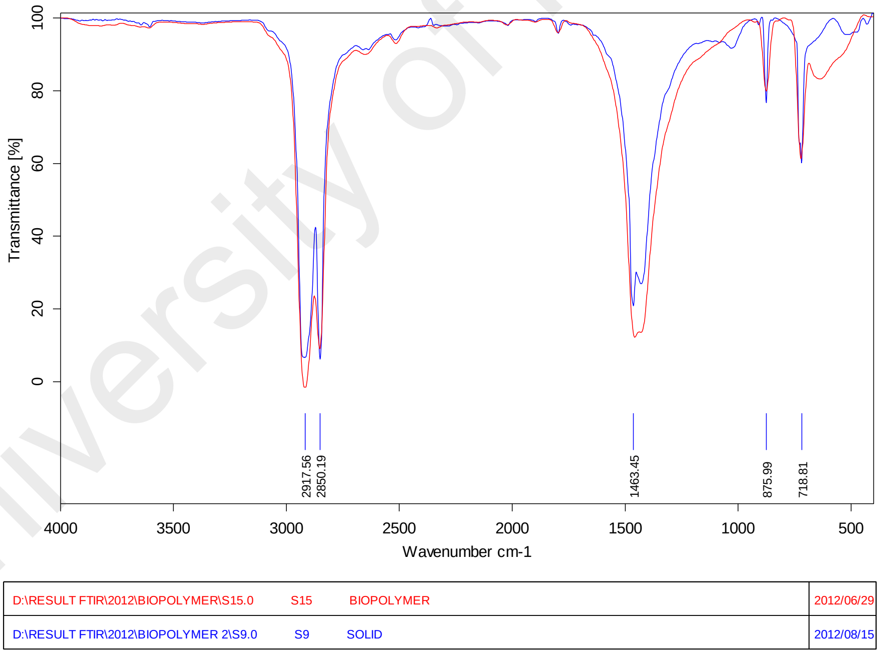


Figure 4.19: Comparison of FTIR Spectra of Biodegradable Plastic Sample Before and After Incubation in Landfill Soil (S6) for 80 Days

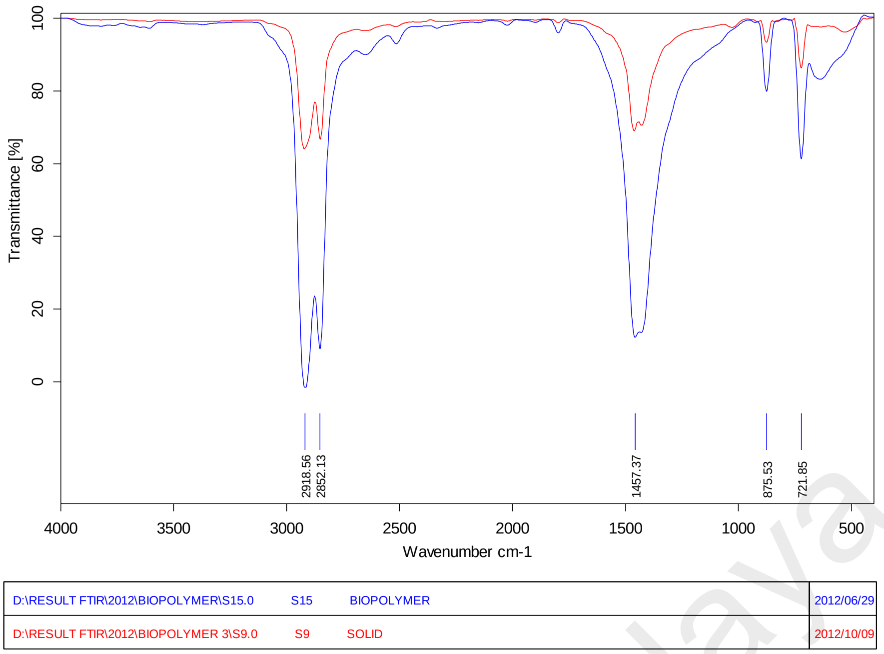


Figure 4.20: Comparison of FTIR Spectra of Biodegradable Plastic Sample Before and After Incubation in Landfill Soil (S6) for 120 Days

Figure 4.21, Figure 4.22 and Figure 4.23 show infrared spectrums of oxo-degradable plastic bag before and after burial in garden soil (S7). Throughout the burial period of 120 days there were no changes on the absorbance peak or new absorbance observed on the spectrum. Thus, there was no formation of carbonyl in this plastic sample. Nonetheless, the intensities for peaks 2919.60 cm^{-1} and 2852.97 cm^{-1} showed improvements in their intensities on Day 80 and continue to improve as observed on Day 120. It indicates that degradation took place in the plastic samples, however it was not intense or long enough to form neither carbonyl nor vinyl groups. As discussed in Allen et al. (2003) increasing concentration and time, hydroxyl, ether, and terminal vinyl groups are formed gradually during degradation.

For peaks 1463.87 cm^{-1} and 723.46 cm^{-1}, the intensities were slightly decreased on Day 80 but then increased on Day 120. This is probably the results of the lower molecular fragments caused by the degradation of the plastic samples. These results are consistent with the weight loss observed in oxo-degradable plastic sample in garden soil (S7).

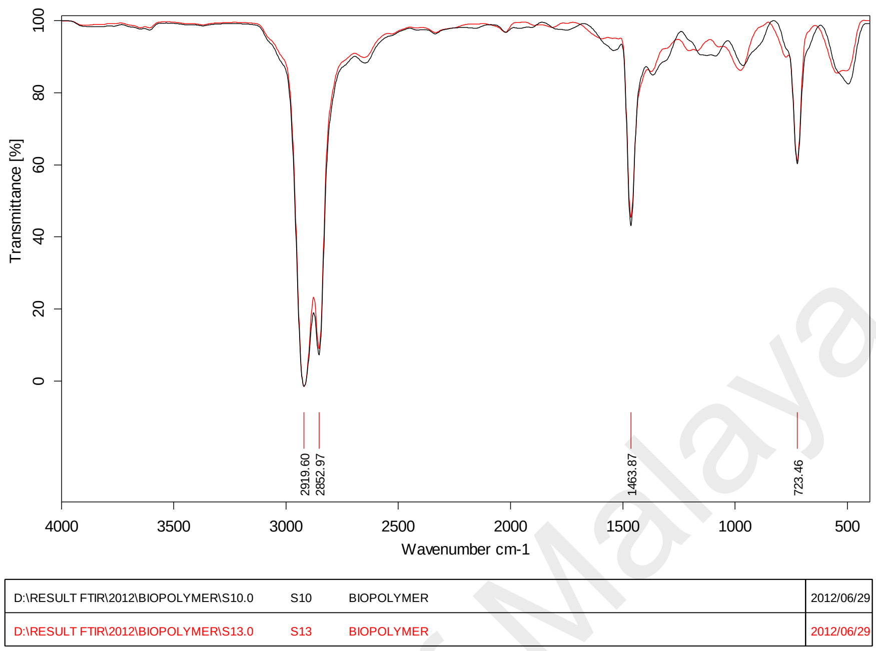


Figure 4.21: Comparison of FTIR Spectra of Oxo-Degradable Plastic Sample Before and After Incubation in Garden Soil (S7) for 40 Days

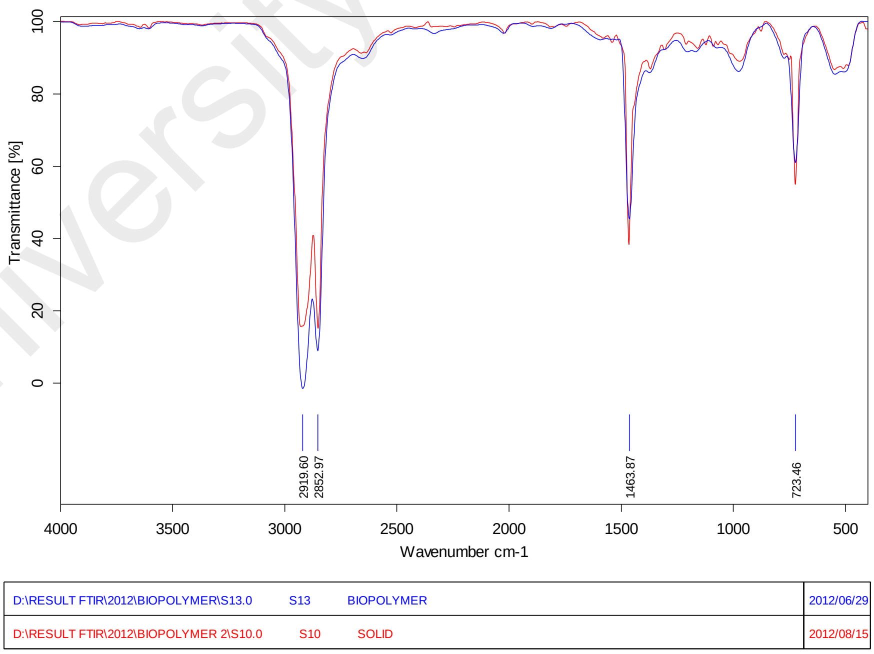


Figure 4.22: Comparison of FTIR Spectra of Oxo-Degradable Plastic Sample Before and After Incubation in Garden Soil (S7) for 80 Days

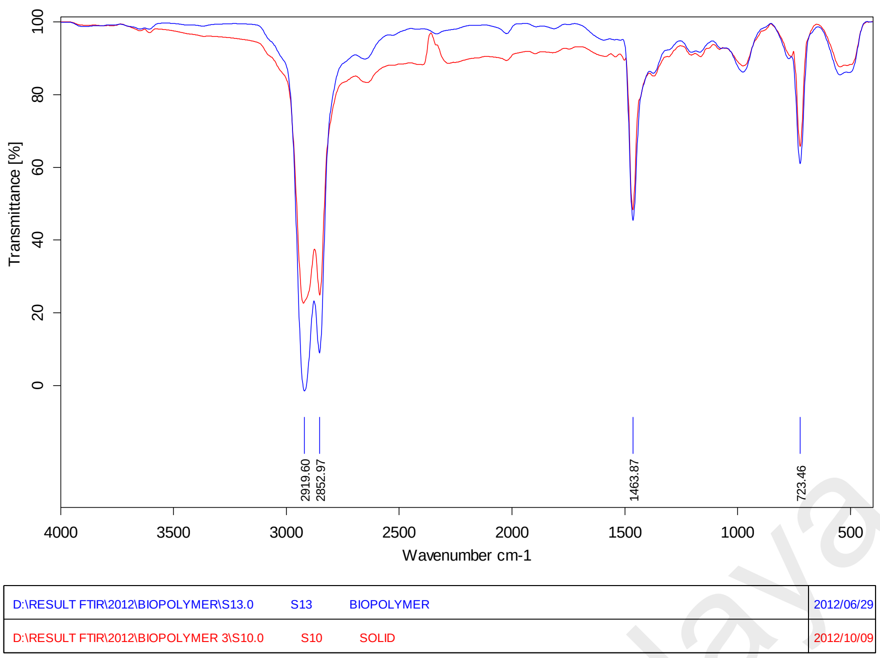


Figure 4.23: Comparison of FTIR Spectra of Oxo-Degradable Plastic Sample Before and After Incubation in Garden Soil (S7) for 120 Days

Figure 4.24, Figure 4.25 and Figure 4.26 show infrared spectrums of oxo-degradable plastic bag before and after burial in compost (S8). Throughout, the burial period of 120 days there was no change on the absorbance peak or new absorbance observed on the spectrum. This indicates there was no formation of carbonyl or vinyl group to prove that degradation took place. Nonetheless, all peaks showed improvements in their intensities on Day 80. On Day 120, only 1463.87 cm^{-1} and 723.46 cm^{-1} continue to show improvements in their intensities. The increase in peak intensities indicates degradation process took place within the plastic samples. These results are consistent with the weight loss observed in oxo-degradable plastic sample in garden soil (S8). However, the degradation was not as intense as in other plastic samples as it is reported to experience the lowest weight loss among all plastic samples.

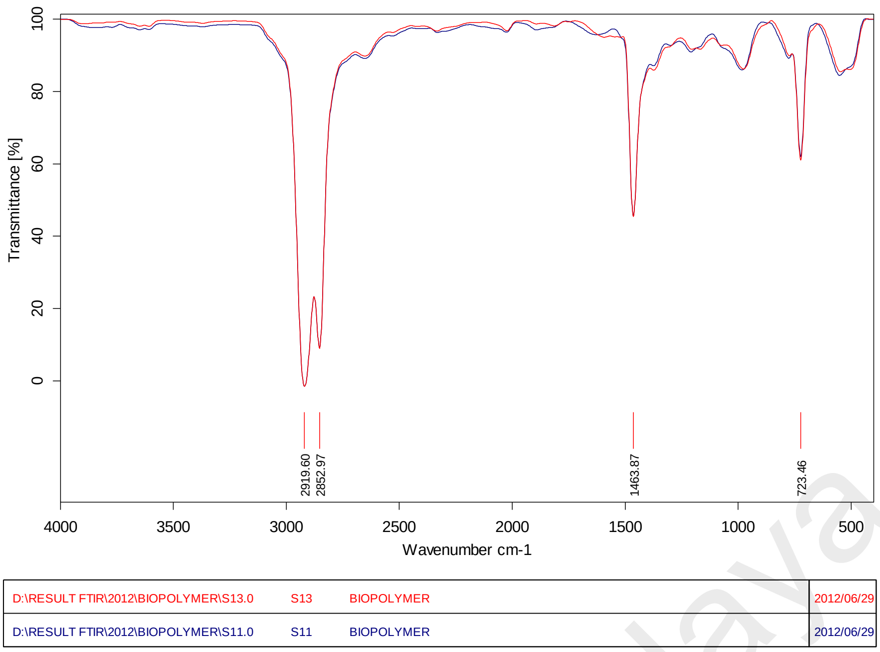


Figure 4.24: Comparison of FTIR Spectra of Oxo-Degradable Plastic Sample Before and After Incubation in Compost (S8) for 40 Days

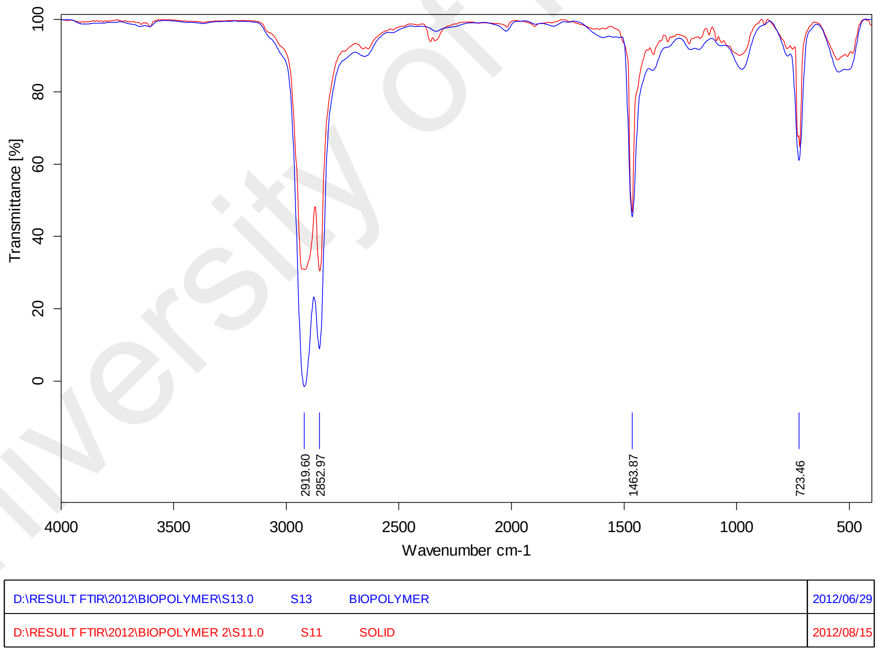


Figure 4.25: Comparison of FTIR Spectra of Oxo-Degradable Plastic Sample Before and After Incubation in Compost (S8) for 80 Days

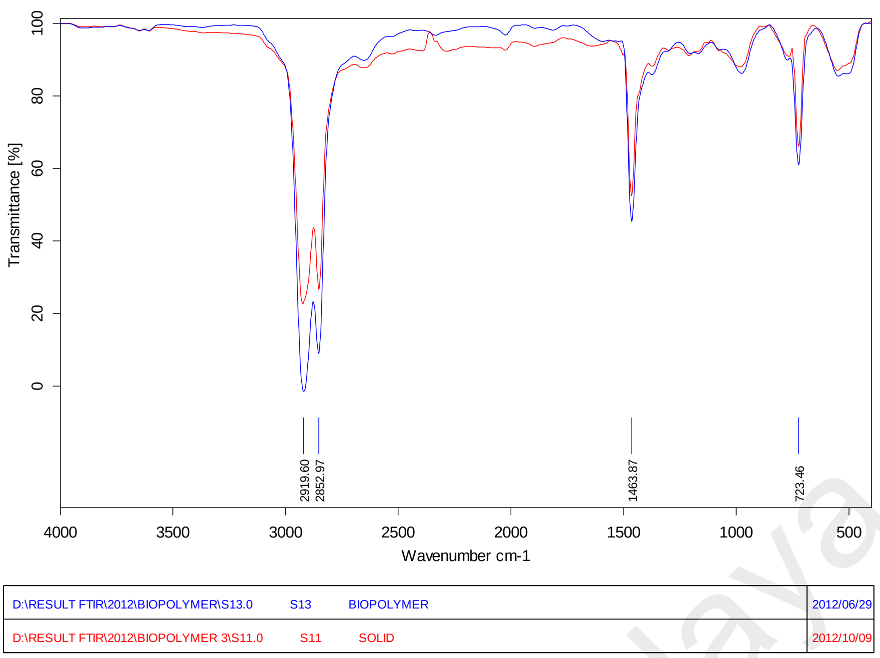


Figure 4.26: Comparison of FTIR Spectra of Oxo-Degradable Plastic Sample Before and After Incubation in Compost (S8) for 120 Days

Figure 4.27, Figure 4.28 and Figure 4.29 show infrared spectrums of oxo-degradable plastic bag before and after burial in landfill soil (S9). Within 120 days of burial there were no changes on the absorbance peak or new absorbance observed on the spectrum. This indicates that there is no formation of carbonyl or vinyl group due to degradation. Nonetheless, there was change in the peak intensities observed. On Day 40, peaks 2852.97 cm^{-1} and 1463.87 cm^{-1} were slightly decreased. On Day 80, all peaks' intensities increased. However, it decreased again on Day 120. The fluctuation of peaks from Day 40 to Day 120 was the resultant of weight loss due to degradation. Weight loss on Day 80 was recorded to be the most intense perhaps due to biodegradation and catalytic degradation after the increase in exposure to microorganism activity and chemical reaction due to metal components in landfill soil. However, biodegradation and catalytic degradation slowed down after Day 80 perhaps due to the limiting factors such as the amount of microorganism activity and metal in landfill soil. Leachate in landfill soil also can deteriorate microorganism activity as reported by Campos et al.

(2012). The intensity decreased on Day 120 could also be due to the utilization of oxidised polymers by microorganisms that decreases the presence of those bonds.

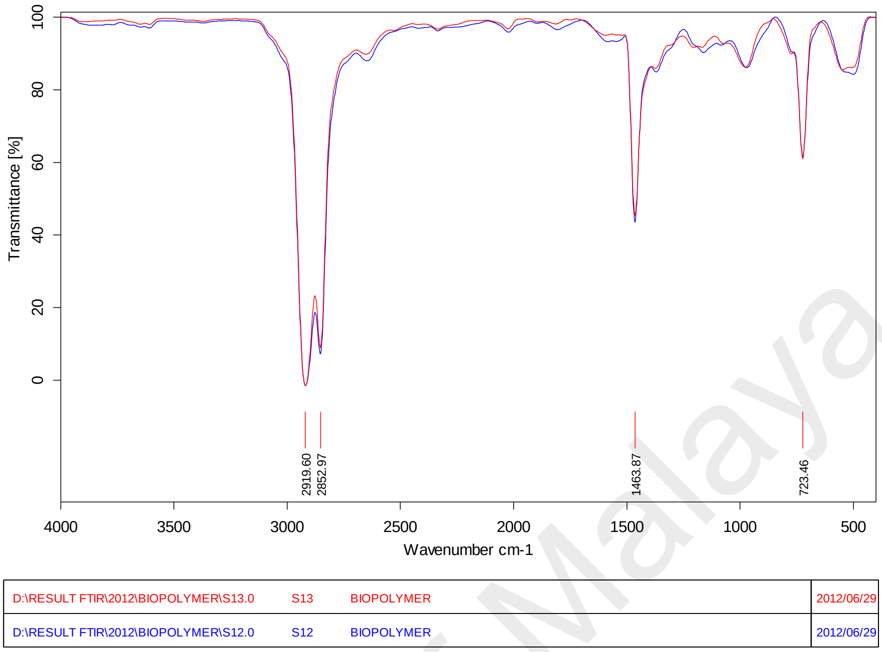


Figure 4.27: Comparison of FTIR Spectra of Oxo-Degradable Plastic Sample Before and After Incubation in Landfill Soil (S9) for 40 Days

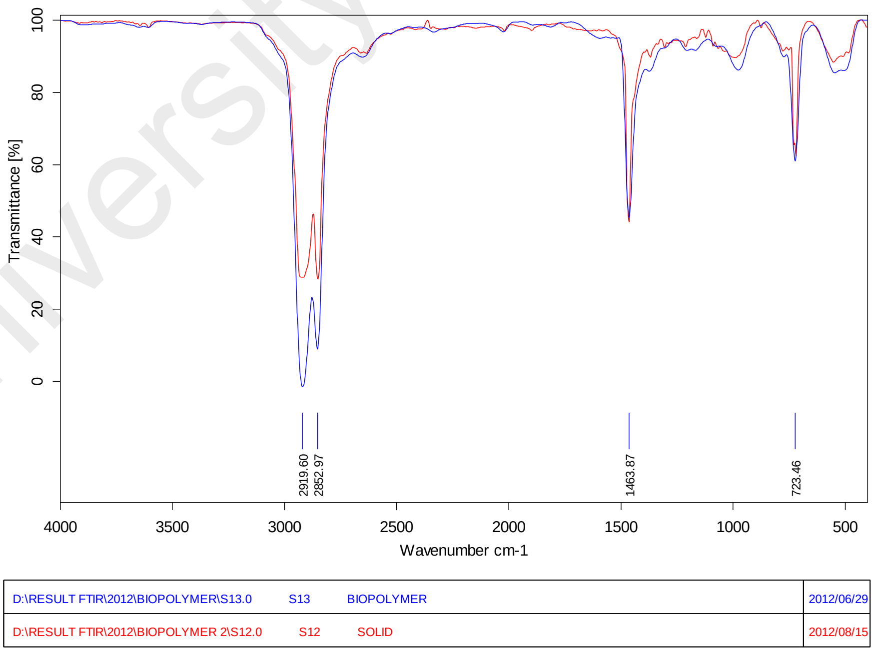


Figure 4.28: Comparison of FTIR Spectra of Oxo-Degradable Plastic Sample Before and After Incubation in Landfill Soil (S9) for 80 Days

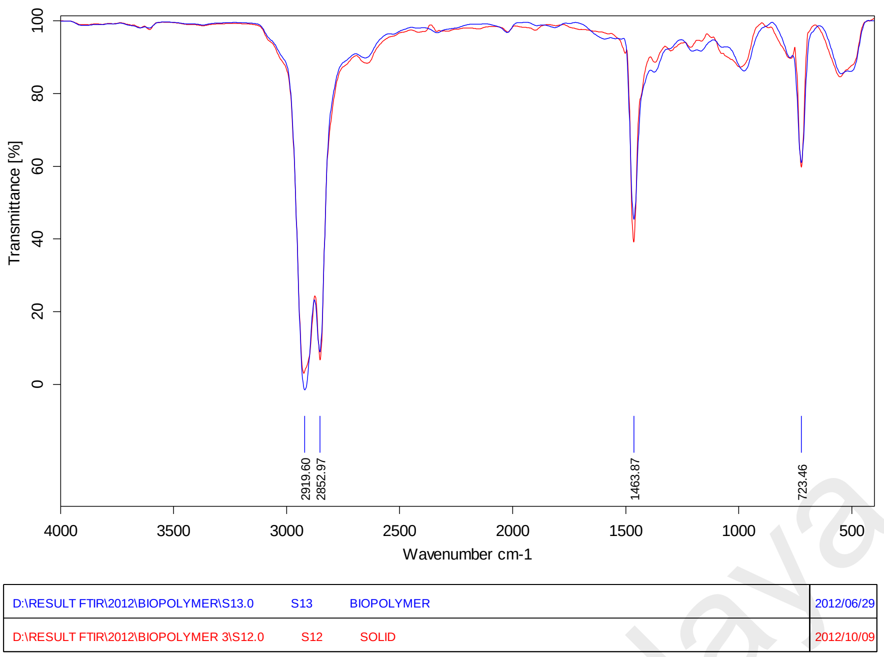


Figure 4.29: Comparison of FTIR Spectra of Oxo-Degradable Plastic Sample Before and After Incubation in Landfill Soil (S9) for 120 Days

All of the plastic samples displayed four types of peaks in the range of 2917 cm^{-1} to 2924 cm^{-1}, 2850 cm^{-1} to 2853 cm^{-1}, 1430 cm^{-1} to 1467 cm^{-1}, and 718 cm^{-1} to 877 cm^{-1}. These are characteristics of polyethylene and polypropylene which was also observed in Cooper & Corcoran (2010). Only biodegradable plastic sample in garden soil (S4), biodegradable plastic sample in compost (S5) and biodegradable plastic sample in landfill soil (S6) display a carbonyl peak at 1797.30 cm^{-1}, which indicates the presence of oxidised material. Similar observation was also seen in Cooper & Corcoran (2010). Biodegradable plastic sample contains starch. Similar to an experiment done by Suhaila (2007), weak carbonyl peak at 1795 cm^{-1} and new absorbance in the 900 cm^{-1} to 1200 cm^{-1} regions were observed in the experiment after 30, 60 and 90 days of burial of the biodegradable plastic sample. This is due to deformation of starch and other lower molecular fragments in the samples. It indicates that degradation process have taken place (Suhaila, 2007). Also, the intensities of peaks at 2918.56 cm^{-1}, 2852.13 cm^{-1}, 1457.37 cm^{-1}, 875.53 cm^{-1} and 721.85 cm^{-1} of the biodegradable plastic samples were observed to improve after 120 days. Shujun et al. (2006) reported similar results of its starch based plastic samples from corn and LLDPE.

Within 120 days, there was no new absorbance observed at the 900 cm^{-1} to 1200 cm^{-1} regions that indicates the presences of vinyl terminal group (Coates, 2000). Similar to carbonyl group formation, vinyl group formation suggest polymer chain scission of HDPE, which probably due to carbonyl degradation by Norrish II (Jabarin & Lofgren, 1994). In the first stage of Norrish type II mechanism, its main products is vinyl group which is then followed by a slower conversion to carbonyl groups (Stark & Matuana, 2004). In this study, the laboratory environment provides minimal UV exposure and heat to stimulate the degradation process. Additionally it is also lack of microorganisms in the medium. Nonetheless, all of the samples showed increase in intensities on Day 120 of burial except for non-degradable plastic sample in landfill soil (S3), oxo-degradable plastic sample in compost (S8) and oxo-degradable plastic sample in landfill soil (S9). The peak intensity improved on Day 80 but reduced again on Day 120. Similarly for non-degradable plastic sample in compost (S2) and oxo-degradable plastic sample in compost (S8) some of the peaks intensity improved on Day 80 However, it lowered on Day 120. The results for oxo-degradable plastic sample in compost (S8) and oxo-degradable plastic sample in landfill soil (S9) are consistent with the weight loss obtained where both recorded the lowest weight loss among all plastic samples. This is due to the fact that oxo-degradable plastic samples need added “prodegradant” additives to trigger and accelerate the degradation process which is not available for S8 and S9.

Singh & Sharma (2008), indicates eleven factors affecting polymer degradation; chemical composition, chemical bonding, methods of synthesis, introduction of functionality, additives, effect of substituent, molecular weight, hydrophobic character, size of the molecules, effect of stress, and environmental conditions. Therefore, in this study, the difference in plastic samples, burial mediums, and laboratory condition have affected the degradation rate of the plastic samples. The following subtopic will discuss the results of the "No Plastic Bag Campaign" in Selangor survey questionnaires.

4.3 Survey Questionnaires

4.3.1 Demographic profile of respondents

The demographic profile of 625 respondents from the nine districts in Selangor is shown in Table 4.19 and Table 4.20. Respondents are between 16 and 60 years of age.

Table 4.19: Frequency Distribution of Respondents by District of Residence

		Frequency	Percent
Valid	Gombak	77	12.3
	Klang	97	15.5
	Kuala Langat	24	3.8
	Kuala Selangor	22	3.5
	Petaling	214	34.2
	Sabak Bernam	10	1.6
	Sepang	24	3.8
	Ulu Langat	136	21.8
	Ulu Selangor	21	3.4
	Total	625	100.0

Table 4.20: Frequency Distribution of Respondents by Age

		Frequency	Percent
Valid	16 – 20	150	24.0
	21 – 25	249	39.9
	26 – 30	112	17.9
	31 – 35	34	5.4
	36 – 40	22	3.5
	41 – 45	22	3.5
	46 – 50	16	2.6
	51 – 55	10	1.6
	56 – 60	10	1.6
	Total	625	100.0

The respondents consist of 40.4% male and 59.6% female from multiracial background (Table 4.21). The ethnicity breakdown of the respondents are 66.1% Malays, 24.0% Chinese, 5.6% Indians and 4.3% others (Table 4.22).

Table 4.21: Frequency Distribution of Respondents by Gender

		Frequency	Percent
Valid	Female	372	59.5
	Male	253	40.5
	Total	625	100.0

Table 4.22: Frequency Distribution of Respondents by Race

		Frequency	Percent
Valid	Chinese	150	24.0
	Indian	35	5.6
	Malay	413	66.1
	Other	27	4.3
	Total	625	100.0

The respondents have diverse educational background from secondary school leavers to PhD holders, as well as, those with no formal educational background. As seen on Table 4.23 majority of the respondents received formal education with the largest group hold a Bachelor's Degree (36.2%) or have at least up to secondary school level education (28.2%).

Table 4.23: Frequency Distribution of Respondents by Highest Level of Education

		Frequency	Percent
Valid	Bachelor's Degree	226	36.2
	Certificate	4	.6
	Diploma	92	14.7
	Master's Degree	58	9.3
	None	2	.3
	PhD	8	1.3
	Professional Paper	4	.6
	Secondary School	176	28.2
	STPM/Matriculation/A-Level or such	55	8.8
	Total	625	100.0

Other than diverse educational background the respondents also have diverse occupation with different levels of income (Table 4.24 and Table 4.25). 50.1% of the respondents work in private sector, 31.5% are students and the rest are self-employed, housewife, retiree, unemployed or work in government sector or government-linked companies. Most of the respondents (24%) do not have income as most of them are students and fresh graduates who are still looking for jobs.

Table 4.24: Frequency Distribution of Respondents by Occupation

		Frequency	Percent
Valid	Government Sector	55	8.8
	Government-Linked Company	2	0.3
	Housewife	6	1.0
	Private Sector	308	49.3
	Retiree	2	0.3
	Self Employed	39	6.2
	Student	203	32.5
	Unemployed	10	1.6
	Total	625	100.0

Table 4.25: Frequency Distribution of Respondents by Income

		Frequency	Percent
Valid	No income	216	34.6
	Less than RM 1,000	72	11.5
	RM 1,000-2,000	94	15.0
	RM 2,001-3,000	75	12.0
	RM 3,001-4,000	72	11.5
	RM 4,001-5,000	39	6.2
	RM 5,001-6,000	10	1.6
	RM 6,001-7,000	8	1.3
	RM 7,001-8,000	8	1.3
	RM 8,001-9,000	9	1.4
	RM 9,001-10,000	12	1.9
	More than RM 10,000	10	1.6
	Total	625	100.0

4.3.2 Respondents' knowledge on plastic bag

Based on the question on which natural resource is used to produce plastic bag, 58.2% responded correctly with petroleum as the answer as shown in Table 4.26. This is probably due to the availability of instant information today where they are able to learn about any subject just by surfing the internet on their mobile devices. This is also probably due to the literacy level of the respondents where 99.7% received formal education at least up to secondary level where they studied basic science subjects.

Table 4.26: Knowledge on the Natural Resource Used to Produce Plastic Bag

		Frequency	Percent
Valid	Animal Oil	15	2.4
	Not sure	226	36.2
	Petroleum	364	58.2
	Vegetable Oil	20	3.2
	Total	625	100.0

The respondents were also asked whether they have received any information on the danger of plastic bag. As shown in Table 4.27, 86.9% of the respondents indicated that they have received information on the danger of plastic bag to the environment. This could also contributed by the high percentage of respondents with knowledge on the natural resource used to produce plastic bag as the discussion on the danger of plastic bag often relates to the production of plastic bag. Knowledge on the danger of plastic bag is crucial to create environmental awareness among the public and encourage the effort to improve plastic waste management. The lack of knowledge on plastic waste could cause a setback in identifying its environmental impact and managing the waste (Perella, 2011).

Table 4.27: Public Awareness on the Danger of Plastic Bag

		Frequency	Percent
Valid	No	82	13.1
	Yes	543	86.9
	Total	625	100.0

When asked about the source of information of the danger of plastic bag, majority of 23.5% claimed that they have received the information from broadcast media such as television and radio as shown in Table 4.28. This is probably due to the availability of broadcast media to all Malaysians regardless of the demographic factors (Roslina et al., 2013). 18.7% indicated that they have received the information from awareness campaign, 13% received the information from published media such as newspaper and books, and 12% from school, university or college. The rest received the information from friends or family, print media such as brochures and pamphlets, and social media such as Facebook and Twitter. The remaining 7.7% have not received any information on the danger of plastic bag.

Table 4.28: Sources of Information on the Danger of Plastic Bag

		Frequency	Percent
Valid	Awareness Campaign	117	18.7
	Broadcast Media	147	23.5
	Friends / Family	43	6.9
	I have never received such information	48	7.7
	Print Media	59	9.4
	Published Media	81	13.0
	School / College / University	76	12.2
	Social Media	54	8.6
	Total	625	100.0

97% of the respondents agreed that plastic bag can cause environmental problems as shown in Table 4.29. Another 3% are either not sure or do not think plastic bag can cause environmental problems. When asked what are the issues related to plastic bag majority of the public relates plastic bag to environmental (91.5%) and public health (59.7%) problems (Table 4.30). This shows the majority of the public are aware of the environmental and public health issues related to plastic bag. Nonetheless, economic, space limitation and aesthetic are also among other major issues related to plastic bag that may not be very well disseminated to the majority of the public yet. Perhaps, this is because environmental and public health problems are more commonly discussed as it has a more direct and obvious impact to the public.

Table 4.29: Opinion on Plastic Bag Can Cause Environmental Problems

		Frequency	Percent
Valid	Yes	606	97.0
	No	8	1.2
	Not sure	11	1.8
	Total	625	100.0

Table 4.30: Issues Related to Plastic Bag

		Frequency	Percent
Valid	Social	139	22.2
	Economic	200	32.0
	Political	53	8.5
	Environmental	572	91.5
	Space Limitation	167	26.7
	Aesthetic	75	12.0
	Public Health	373	59.7

When asked on environmental issues related to plastic bag majority relates it to water pollution (60.3%), land pollution (70.4%), and deterioration of environment's natural beauty (65/%) as shown on Table 4.31. Very small percentage (2.7%) is not aware of the environmental problems related to plastic bag or relates it to sound pollution which may not be directly related to plastic bag. In support of the findings in Table 4.29, it can be concluded that majority of the public are aware on the environmental problems related to plastic bag.

Table 4.31: Environmental Issues Related to Plastic Bag

		Frequency	Percent
Valid	Unintended death of animals	305	48.8
	Water pollution	377	60.3
	Land pollution	440	70.4
	Air pollution	190	30.4
	Sound pollution	14	2.2
	No pollution	3	0.5
	Depletion of non-renewable resources	270	43.2
	Deterioration of environment's natural beauty	406	65.0

Based on the public's personal observations in Table 4.32, areas observed to be most polluted with plastic bag are waste dumping sites (48.5%), drainage (40.3%), residential areas (36.3%), river (33.9%), wet market (25.8%), recreational parks (23.8%), roadsides (17.3%), industrial areas (16.6%), sea (14.9%), supermarket/hypermarket (13.6%), and shopping malls (12.2%). The high amount of waste observed at waste dumping sites is also supported by "Global plastic production rises" (2015) where it is reported 22% to 43% of the plastic used globally ends up in landfills. Drainage, residential areas and river were also mostly observed to be most polluted by plastic bag. Perhaps this is because these areas are more densely populated. Other public areas with lesser observation to be polluted with plastic bag such as wet market, recreational parks, industrial areas, supermarket/hypermarket and shopping malls may have waste dumping facilities for the public to properly discard their plastic bag.

Table 4.32: Areas Most Polluted with Plastic Bag

		Frequency	Percent
Valid	Residential areas	227	36.3
	Industrial areas	104	16.6
	Recreational parks	149	23.8
	Roadsides	108	17.3
	Waste dumping sites	303	48.5
	Sea	93	14.9
	River	212	33.9
	Drainage	252	40.3
	Shopping malls	76	12.2
	Wet market	161	25.8
	Supermarket/Hypermarket	85	13.6

As shown on Table 4.33, 62.7% of the public is finds it very important to raise awareness on the danger of plastic bag to the environment and 34.6% finds it important. Perhaps, this is because majority of the respondents are aware of the danger of plastic bag on the environment and environmental issues related to it.

Table 4.33: Opinion on the Importance to Raise Awareness on the Danger of Plastic Bag to the Environment

		Frequency	Percent
Valid	Very Important	392	62.7
	Important	216	34.6
	Unimportant	9	1.4
	Very Unimportant	8	1.3
	Total	625	100.0

The analysis showed that gender is a statistically significant predictor of the tendency to receive information on the danger of plastic wastes (Correlation Coefficient, r = 0.095, p<0.05) (Table 4.34). This shows that 9.5% of the variance in the tendency receiving information on the danger of plastic wastes to the environment can be explained by the gender of the respondents. 61% of the respondents who have received information on the danger of plastic wastes to the environment are female respondents. Perhaps this is because female respondents are more inclined to understanding environmental problems. This is supported by Zelezny et al. (2000) where women are reported to be more socially responsible, and possess stronger environmental behaviours and attitudes than men. Additional to that Mohai (1992) also reported women have greater environmental concern than men although their environmental activism is substantially lower than men. This perhaps can be explained by Organization for Security and Co-operation in Europe (2009) which reported that women are more impacted by the consequences of environmental problems due to the roles they play in the family, community and work-force. Additionally the findings in Asmuni et al. (2015) revealed female customers are mostly the ones who brought their own bags when shopping. The study was mostly done in shopping area and most of the shopping is done by female similarly to the study by Zen et al. (2013) which was focused in hypermarkets where 60% of the respondents were female.

Table 4.34: Relationship between Gender and the Tendency to Receive Information on the Danger of Plastic Wastes to the Environment

		Gender	Tendency to receive information on the danger of plastic wastes to the environment
Gender	Pearson Correlation	1	.095*
	Sig. (2-tailed)		.018
	N	625	625
Tendency to receive information on the danger of plastic wastes to the environment	Pearson Correlation	.095*	1
	Sig. (2-tailed)	.018	
	N	625	625

*. Correlation is significant at the 0.05 level (2-tailed).

The following parameters do not have significant effects on getting information on the danger of plastic waste; district of residents, age, race, highest level of education, occupation and income level. Perhaps this is due to the respondents' behaviour and lifestyle.

4.3.3 Respondents' plastic bag usage

Although 86.9% claimed that they have received information on the danger of plastic waste, 73.8% responded that they still discard 1 to 5 pieces of plastic bags daily as shown in Table 4.35. Another 11.7% do not use plastic bags daily, 8.5% discard more than 10 pieces daily and 6.1% discard 6 to 10 pieces of plastic bag daily. Table 4.36 shows 84.3% of the respondents use plastic bags to collect garbage, 69.6% use it to takeaway food and 58.2% use it during shopping. Only 1.1% of the respondents claimed that they do not use plastic bags at all. The high usage of plastic bags for the purposes of shopping and food takeaway can be explained by Table 4.37 where it shows 27% of the respondents indicated that they prefer using plastic bag because it is easily available at the shops. Another 17.6% claims they prefer to use plastic bag because it is provided for free by shops and retailer. Plastic bags from shops and retailers will be used as garbage bags. The banning of plastic bags has just been extended to every day in Selangor starting January 2017. When the study was conducted plastic bag is still made available for the consumers every other day and with a fee of RM0.20 on Saturday (Dharmender, 2011). These are perhaps the reasons why despite of the knowledge on the danger of plastic bags, the respondents are still dependent on it.

Table 4.35: Amount of Plastic Bag Discarded Daily

		Frequency	Percent
Valid	0	73	11.7
	1 to 5	461	73.8
	6 to 10	38	6.1
	More than 10	53	8.5
	Total	625	100.0

Table 4.36: Reasons for Using of Plastic Bags

		Frequency	Percent
Valid	Collecting garbage	527	84.3
	Takeaway food	435	69.6
	Shopping	364	58.2
	I do not use plastic bags	7	1.1

Table 4.37: Reasons for Preference Using Plastic Bags

		Frequency	Percent
Valid	Durability	38	6.1
	Easily available	169	27.0
	I do not use plastic bag	76	12.2
	Lack of alternative materials	69	11.0
	Light in weight	88	14.1
	Low cost	75	12.0
	Provided for free by shops and retailers	110	17.6
	Total	625	100.0

As for discarding the plastic bags, 86.9% of the respondents claim that they will discard their plastic wastes in garbage bins a shown in Table 4.38. The rest discard their plastic wastes in open space (6.9%) or bury it (4.6%). A very small percentage (1.6%) sends their plastic wastes to recycling centre. Although majority of 97% claims to know that plastic bag can cause environmental problems as shown in Table 4.29 earlier, not many take action to recycle their plastic bag. This finding is supported by Berenguer et al. (2005) where all of its samples demonstrated high levels of environmental concern however demonstrated low levels of positive environmental attitude and behaviour.

Table 4.38: Ways to Discard Plastic Bags

		Frequency	Percent
Valid	Garbage bin	543	86.9
	Open space	43	6.9
	Burying	29	4.6
	Recycling	10	1.6
	Total	625	100.0

Pearson correlation was used to analyse the relationship between district of residence and the amount of plastic bag discarded daily. The analysis in Table 4.39 shows that district of residence or locality is a statistically significant predictor of the amount of plastic bag discarded daily by the respondents (Correlation Coefficient, $r = 0.126$, $p<0.05$). This shows that 12.6% of the variance in the amount of plastic bag discarded daily by the respondents is strongly related to the locality of residents. The respondents who reside in Petaling, Ulu Selangor and Klang have more than 85% respondents who tend to discard lesser plastic bags between 0 to 5 plastic bags daily as compared to other districts. District such as Gombak and Kuala Langat have more than 20% respondents who discard 6 to more than 10 plastic bags daily while respondents from other district only less than 20% discard plastic bags in that amount. Perhaps this is because the respondents from the different districts possess different socialization experiences which form their environmental values, attitudes, and behaviours. Similarly, a study done in rural American communities in Iowa found that place and community of attachment are one of the strongest predictors of pro-environmental behaviours (Takahashi et al., 2015). Berenguer et al. (2005) made comparisons between urban and rural samples and found that urban samples showed higher levels of environmental concern and rural samples showed higher levels of positive environmental attitude and behaviour. Another study by Asmuni et al. (2015) also discovered a significant link between location of the store and the amount consumers pay for the plastic bag levy. The study discovered 50% of the consumers chose not to pay for the plastic bag perhaps due to the awareness on the plastic bag campaign in stores located in central region such as Kuala Lumpur Putrajaya. On the other hand in stores located in other regions such as Penang and Kedah the number of those who chose to pay for the plastic bag levy is higher (Asmuni et al., 2015). The state government may need to put in more thoughts on the campaign approach to different districts in Selangor due to this finding, customisation may need to be put in place to educate the public on the campaign in different districts in Selangor to ensure the effectiveness of the campaign.

Table 4.39: Relationship between District of Residence and the Amount of Plastic Bag Discarded Daily

		District of residence	Amount of plastic bag discarded daily
District of residence	Pearson Correlation	1	.126**
	Sig. (2-tailed)		.002
	N	625	625
Amount of plastic bag discarded daily	Pearson Correlation	.126**	1
	Sig. (2-tailed)	.002	
	N	625	625

Pearson correlation was also used to test the correlation between level of education and the amount of plastic bag discarded daily by the respondents (Table 4.40). The results show that level of education is statistically correlated to the amount of plastic bag discarded daily (Correlation Coefficient, $r = 0.116$, $p<0.05$). This shows that 11.6% of the variance in the amount of plastic bag discarded daily by the respondents is positively related to the respondents' level of education. 52% respondents who discard 0 to 5 plastic bags daily have at least higher education background (Bachelor's Degree and above). On the other hand, 80% of the respondents who discard 6 to more than 10 plastic bags daily do not possess higher education. Perhaps this is because respondents with higher level of education have received better exposure to the danger of plastic waste to the environment and living organisms and this makes them more inclined to use less plastic bag. Owen et al. (2010) also reported similar findings where individuals who came from a population which has more individuals with post-graduate degrees are observed to be stronger environmentalist.

Table 4.40: Relationship between the Highest Level of Education and the Amount of Plastic Bag Discarded Daily

		Highest level of education	Amount of plastic bag discarded daily
Highest level of education	Pearson Correlation	1	.116**
	Sig. (2-tailed)		.004
	N	625	625
Amount of plastic bag discarded daily	Pearson Correlation	.116**	1
	Sig. (2-tailed)	.004	
	N	625	625

Majority of those who discard more than 10 plastic bags in a day reside in Ulu Langat and have up to secondary education. Perhaps there was less exposure to the danger of plastic waste, in the area where they reside. Implementation of more environmental awareness campaigns in commercial areas, as well as, in schools in Ulu

Langat would be beneficial to increase the awareness level of the public in that area and eventually decreases their usage of plastic bags. Majority of the public also indicated that plastic bag is easily available and this is the reason why they prefer to use plastic bag. In this case, the environmental awareness campaign on the danger of plastic bag should be coupled with the "No Plastic Bag Campaign" targeting retail outlets. Reusable bag can also be provided by the retailers with a minimal fee. This finding may also explain how locality is a statistically significant predictor of the amount of plastic bag discarded daily by the respondents. Respondents from Petaling, Klang and Ulu Selangor whom 63% of the population possessed least a Bachelor's Degree also have the majority respondents who discarded the least plastic bag. Age, gender, occupation and income level have no significant influence to the amount of plastic bag discarded daily.

4.3.4 Respondents' awareness on the "No Plastic Bag Campaign" in Malaysia

When asked about whether the respondents know about the "No Plastic Bag Campaign" in Malaysia, 91.2% of the respondents responded "Yes" that they know about the campaign (Table 4.41). The positive responds are probably due to advertisement and the wide implementation coverage of the campaign in major retail outlets in Selangor such as Carrefour, Tesco, Giant, AEON (previously known as Jusco) and Ikea ("Retailers go all out," 2010).

Table 4.41: Public Awareness on "No Plastic Bag Campaign" in Malaysia

		Frequency	Percent
Valid	No	55	8.8
	Yes	570	91.2
	Total	625	100.0

However, the details of the "No Plastic Bag Campaign" in Malaysia may not be very clear to most of the public in Selangor. Only 15.4% knows the exact launch date which is on January 2011 (Table 4.42). Majority of 61.4 % are not sure of the exact launch date of the campaign. Table 4.43 shows only 11.1% are aware that the Ministry of Domestic Trade, Cooperatives and Consumerism launched the "No Plastic Bag Campaign" in Malaysia. Nonetheless, 90.4% are aware of the objectives of the "No Plastic Bag Campaign" in Malaysia (Table 4.44) which are to reduce solid waste, to instil environment friendly values among the public and businesses, and to support the government effort to preserve the environment and the depleting resources (Dharmender, 2011).

Table 4.42: Launch Date of the "No Plastic Bag Campaign" in Malaysia

		Frequency	Percent
Valid	Correct	96	15.4
	Incorrect	145	23.2
	No sure	384	61.4
	Total	625	100.0

Table 4.43: Ministry That Launched the "No Plastic Bag Campaign" in Malaysia

		Frequency	Percent
Valid	Correct	69	11.1
	Incorrect	294	47.0
	No sure	262	41.9
	Total	625	100.0

Table 4.44: Objective of the "No Plastic Bag Campaign" in Malaysia

		Frequency	Percent
Valid	Correct	565	90.4
	Incorrect	54	8.6
	No sure	6	1.0
	Total	625	100.0

Additional to that, when asked on the theme of the “No Plastic Bag Campaign” in Malaysia only 27.4 % know the theme of the campaign which is “Safe Our Future Generation and Earth” (Table 4.45). Table 4.46 shows 89.6% of the majority of the public are aware of the official day of the “No Plastic Bag Campaign” in Malaysia which is on Saturday. Perhaps some of the respondents who answered other than Saturday may experience no plastic day other than on Saturday such as in Penang where the “No Plastic Bag Day” have been implemented earlier than Selangor (Frequently asked question, 2012). Also some retailers such as IKEA have stopped giving out plastic bags since July 1st, 2011 (Local efforts, n.d.). Also, when asked on which states have participated on the “No Plastic Bag Day” before the nationwide launch, only 16.2% are aware that Penang and Selangor were the early supporters of the campaign (Table 4.47).

Table 4.45: The Theme of the “No Plastic Bag Campaign” in Malaysia

		Frequency	Percent
Valid	Correct	171	27.4
	Incorrect	194	31.0
	No sure	260	41.6
	Total	625	100.0

Table 4.46: Enforcement Day of the “No Plastic Bag Campaign”

		Frequency	Percent
Valid	Correct	560	89.6
	Incorrect	26	4.2
	No sure	39	6.2
	Total	625	100.0

Table 4.47: Early Participating States in the "No Plastic Bag Day"

		Frequency	Percent
Valid	Correct	101	16.2
	Incorrect	499	79.8
	No sure	25	4.0
	Total	625	100.0

As shown on Table 4.48, 86% are aware plastic bag is charged 20 cents per piece on the "No Plastic Bag Day". As the campaign has been running for a few years now most of the public have come to know that plastic bags are going to be charged 20 cents on every Saturday. Table 4.49 shows only 38.7% of the respondents are aware that the money collected from the sales of plastic bag on "No Plastic Bag Day" is channelled into a special fund used to conduct environment protection and preservation related activities and programmes for communities and consumers (Dharmender, 2011).

Table 4.48: Price of Plastic Bag on the "No Plastic Bag Day"

		Frequency	Percent
Valid	Correct	537	86.0
	Incorrect	64	10.2
	No sure	24	3.8
	Total	625	100.0

Table 4.49: Usage of Funds Collected on the "No Plastic Bag Day"

		Frequency	Percent
Valid	Correct	242	38.7
	Incorrect	115	18.4
	No sure	268	42.9
	Total	625	100.0

When asked on the public on the appropriate price to be charged for a piece of plastic bag. 79.4% of the respondents suggested increasing the price between 25 cents up to 5

Malaysian Ringgit for a piece of plastic bag (Table 4.50). 10.7% are comfortable with the current price of 20 cents and minority of 7% suggested lesser than 20 cents and 2.9% wants plastic bags to remain free. Perhaps, this can be due to the high awareness level among the public on the danger of plastic bag wastes to the environment.

Table 4.50: Opinion on Price of Plastic Bag

		Frequency	Percent
Valid	Increase	496	79.4
	Maintain	67	10.7
	Lesser	44	7.0
	Free	18	2.9
	Total	625	100.0

As shown on Table 4.51, 58.6% of the respondents find that the “No Plastic Bag Campaign” is effective at reducing plastic bag usage and 22.1% finds it very effective. Only a minority of 13.8% finds it ineffective and 5.5% finds it very ineffective at reducing plastic bag usage. Majority responded positively when asked whether the “No Plastic Bag Campaign” is beneficial to the environment. As shown on Table 4.52 54.6% strongly agree with the statement and 42.7% agree. Similarly to the question on whether “No Plastic Bag Campaign” is beneficial to the public, majority responded positively to it. Table 4.53 shows 43% strongly agreed and 46.2% agree that the campaign is beneficial to the public. Thus, it can be concluded that the “No Plastic Bag Campaign” is positively accepted by majority of the public as they believe the campaign is beneficial to them and the environment.

Table 4.51: Opinion on Effectiveness of the "No Plastic Bag Campaign" on Reducing Plastic Bag Usage

		Frequency	Percent
Valid	Very Effective	138	22.1
	Effective	366	58.6
	Ineffective	86	13.8
	Very Ineffective	35	5.5
	Total	625	100.0

Table 4.52: Opinion on Benefit of the "No Plastic Bag Campaign" to the Environment

		Frequency	Percent
Valid	Strongly Agree	341	54.6
	Agree	267	42.7
	Disagree	12	1.9
	Strongly Disagree	5	0.8
	Total	625	100.0

Table 4.53: Opinion on Benefit of the "No Plastic Bag Campaign" to the Public

		Frequency	Percent
Valid	Strongly Agree	269	43.0
	Agree	288	46.2
	Disagree	54	8.6
	Strongly Disagree	14	2.2
	Total	625	100.0

When asked on the best way to promote the "No Plastic Bag Campaign" in Malaysia, 21.2% suggested through broadcast media such as television and radio (Table 4.54). Perhaps, this is because broadcast media is more common and is the most accessible means to the public. 18.8% suggested through social media which is the fastest way to disseminate information today. 18% suggested published media such as newspaper and books to promote the campaign effectively. 12.4% suggested campaigns to be held in schools, colleges and universities. This way it can reach out the younger generations and create awareness in them at an early age. 11.3% suggest print media such as printing brochures and pamphlets to be given out to public. 9.4% finds it most effective if the campaign is promoted by family and friends. Perhaps, the personal touch will create more interest in the campaign. 8.9% suggested seminars or lectures to be held to promote the campaign.

Table 4.54: Opinion on the Best Way to Promote the "No Plastic Bag Campaign" in Malaysia

		Frequency	Percent
Valid	Broadcast media (television, radio etc.)	133	21.2
	Social media (Facebook, Twitter, blog etc.)	119	18.8
	Published media (newspaper, book etc.)	113	18.0
	Print media (brochures, pamphlets etc.)	71	11.3
	Seminar/lecture/etc.	56	8.9
	School/college/university/etc.	76	12.4
	Friends/family/etc.	57	9.4
	Total 2527	625	100.0

Table 4.55 shows the respondents' various sources of obtaining information on the "No Plastic Bag Campaign" in Malaysia. The results of the study indicated that 77.7% of the respondents knew about the campaign through media such as broadcast media, print media, published media and social media with broadcast media being the highest (28.6%). This is agreeable with United Nations Environment Programme (UNEP) (2007), where media is regarded as a powerful tool to create public awareness. 8.5% of the respondents knew about the campaign through advertisement at shops in shopping malls, supermarket, hypermarket and such. Another 5.9% found out about the campaign through friend or family, and another 5% found out about the campaign in school, university or college. The remaining 2.9% have not heard about the campaign at all. The

respondents who do not know about the “No Plastic Bag Campaign” may have been ignorant to their surrounding and may have overlooked the campaign.

Table 4.55: Sources of Information on the “No Plastic Bag Campaign” in Malaysia

		Frequency	Percent
Valid	Broadcast Media	179	28.6
	Friends / Family	37	5.9
	I have not heard of the campaign	18	2.9
	Print Media	77	12.3
	Published Media	137	21.9
	School / College / University	31	5.0
	Shops	53	8.5
	Social Media	93	14.9
	Total	625	100.0

Pearson correlation showed that ethnicity is a statistically significant predictor of the awareness on the “No Plastic Bag Campaign” in Malaysia (Correlation Coefficient, $r = 0.081$, $p<0.05$) (Table 4.56). This shows that 8.1% of the variance in the awareness on the “No Plastic Bag Campaign” in Malaysia can be explained by the respondents’ ethnicity. Respondent’s awareness on the “No Plastic Bag Campaign” in Malaysia varies in different races. 60% of the respondents who are aware of the “No Plastic Bag Campaign” in Malaysia are Malays. This is perhaps due to social heritage and culture of the Malay community that make them more inclined to receive information on the “No Plastic Bag Campaign” in Malaysia. Similar observation was found in a survey conducted in New Jersey, where certain ethnicities in America possessed greater environmental concern on air pollution issue than the others (Greenberg, 2005). The current race proportion in Malaysia might also be the reason for the higher awareness among the Malay ethnicity which made up 50.1% of the Malaysia population (“Malaysia Demographics,” 2016).

Table 4.56: Relationship between Race and the Awareness on the "No Plastic Bag Campaign" in Malaysia

		Race	Awareness on the "No Plastic Bag Campaign" in Malaysia
Race	Pearson Correlation	1	.081*
	Sig. (2-tailed)		.043
	N	625	625
Awareness on the "No Plastic Bag Campaign" in Malaysia	Pearson Correlation	.081*	1
	Sig. (2-tailed)	.043	
	N	625	625

The "No Plastic Bag Campaign" approach should be more holistic to reach out to all Malaysians regardless of race. Perhaps, as most of the campaign promotion was done via broadcast media this may have been one of the limiting factor on the awareness of the campaign as people are more likely to get information online rather than on broadcast media nowadays. Campaign promotion through social media should be increased as it is more efficient due to higher accessibility through mobile devices. District of residents, age, gender, highest level of education, occupation and income level have no significant influence to the awareness on the "No Plastic Bag Campaign" in Malaysia.

4.3.5 Respondents' willingness to shop without plastic bag

When asked if they have taken any initiative to reduce the usage of plastic bags, 76.5% responded with a "Yes" (Table 4.57). The public was also asked if they think the production of plastic bag should be continued or discontinued. Table 4.58 shows approximately 74.1% of the respondents agree for the usage of plastic bags to be discontinued. This shows that majority of the public are supportive on the banning of plastic bags. This is due the high awareness on the danger of plastic bag to the environment among respondents as showed on Table 4.29 as 97%. Table 4.59 also supports this where 67% responded the reason they reduce the usage of plastic bags is because of their knowledge on the danger of plastic bag to the environment.

Table 4.57: Taken Action to Reduce the Usage of Plastic Bags

		Frequency	Percent
Valid	No	147	23.5
	Yes	478	76.5
	Total	625	100.0

Table 4.58: Public Opinion on the Discontinuation of Plastic Bags Usage

		Frequency	Percent
Valid	Continued	162	25.9
	Discontinued	463	74.1
	Total	625	100.0

Table 4.59: Reasons to Reduce the Usage of Plastic Bags

		Frequency	Percent
Valid	Availability of alternative materials	149	23.8
	Chargeable plastic bags	57	9.1
	Knowledge on the danger of plastic bag wastes to the environment	419	67.0
	Total	625	100.0

When asked on their opinion on the responsible entity to discontinue the usage of plastic bags, 27% of the public feel the government and the public itself should be held responsible (Table 4.60). 18.2% feels the responsibilities should lies within the environmental agencies responsibilities, 15% feels it should be the municipalities, 11% with NGOs and 0.8% feels it should be the business owners responsibilities. This shows a sense of ownership on reducing the usage of plastic bags. The public feels the government should be held responsible perhaps because the government does play a huge role in introducing and enforcing law and policies related to plastic wastes management.

Table 4.60: Opinion on Responsible Entity to Discontinue Usage of Plastic Bags

		Frequency	Percent
Valid	Municipality	244	15
	NGO	191	11.7
	Government	442	27.1
	Environmental agencies	296	18.2
	The public itself	443	27.2
	Business owners	13	0.8

However, the discontinuation of plastic bag usage could only work if alternative to plastic bags are made available to the public. When asked on the best alternative option to plastic bags majority of 62.2% feels that reusable bag is the best option (Table 4.61). Additional to Table 4.62 shows that 74.1% claims they already own reusable bag / alternative option to the conventional plastic bag. Nonetheless, the popular alternative chosen by many retailers is to replace conventional plastic bags with degradable plastic bags. However, only 0.5% of the public thinks that degradable plastic bag is the best alternative option to plastic bag. Perhaps, the public are not aware of the benefits of using degradable plastic bag as the effectiveness of degradable plastic bag to curb environmental issue caused by plastic remains uncertain.

Table 4.61: Opinion on the Best Alternative to Plastic Bag

		Frequency	Percent
Valid	Box	42	6.7
	Paper bag	191	30.6
	Reusable bag	389	62.2
	Degradable plastic bag	3	0.5
	Total	625	100.0

Table 4.62: Ownership of Reusable Bag / Alternative Option

		Frequency	Percent
Valid	Yes	463	74.1
	No	162	25.9
	Total	625	100.0

In terms of the public knowledge on waste management systems available out there, 54.9% are supportive towards waste management systems such as Incineration, Refuse Derived Fuel and Biogas (Table 4.63). Perhaps, the public understands the advantage of these waste management systems to manage waste more effectively than landfilling. It is also made know to the public that landfill space is currently filling up fast in Malaysia as reported by Agamuthu & Fauziah (2011). However, 34.9% of the public are still not aware of the existence of such systems. This is still a large portion of the public who are not aware of how waste is managed.

Table 4.63: Supportive Towards Waste Management Systems (Incineration, Refuse Derived Fuel, Biogas etc.)

		Frequency	Percent
Valid	Yes	343	54.9
	No	64	10.2
	Never heard of such systems	218	34.9
	Total	625	100

The analysis showed that level of education is statistically significant to respondents' willingness to discontinue plastic bag usage (Correlation Coefficient, $r = 0.080$, $p<0.05$) (Table 4.64). This shows that 8.0% of the variance in the respondents' willingness to discontinue plastic bag usage can be explained by the respondents' level of education. 50% of those possess higher education are more willing to discontinue plastic bag usage and 60% of those without higher education are not willing to discontinue plastic bag usage. 76% of those who have with post-graduate background are supportive with discontinuation of plastic bag usage. This is again supported by findings by Owen et al. (2015) where most individuals who are stronger environmentalist possessed post-graduate degrees.

Table 4.64: Relationship between Highest Level of Education and the Willingness to Discontinue Plastic Bag Usage

		Highest level of education	Willingness to discontinue plastic bag usage
Highest level of education	Pearson Correlation	1	.080*
	Sig. (2-tailed)		.046
	N	625	625
Willingness to discontinue plastic bag usage	Pearson Correlation	.080*	1
	Sig. (2-tailed)	.046	
	N	625	625

Majority of those who responded negatively to the discontinuation of plastic bag usage have at least up to secondary school education. Perhaps their exposure to the danger of plastic waste is limited resulting with limited understanding on the issue. Those who have higher education tend to be more supportive towards the discontinuation of plastic bag usage. They may have been more exposed to the issue surrounding plastic waste that encourages them to be more supportive towards the discontinuation of plastic bag usage. Thus, it can be derived that respondents with higher education are more supportive towards the discontinuation of plastic bag usage in Malaysia.

4.4 General Discussion

One of the main objectives of the study is to determine the degradability rates of selected types of plastic bags via soil burial test. In view of this, the weight loss observation on the three (3) types of plastic samples indicate that non-degradable plastic bag in garden soil has the highest weight loss with 10.2% of weight loss after 120 days. This is however inconsistent with the findings from HDPE, LDPE (2013), Lajeunesse (2004) and “What are the differences” (2008) which report HDPE materials to have high tensile strength, high crystallinity and rigid than LDPE and LLDPE materials. Ojeda et al. (2009) also recorded that biodegradable plastic have higher degradability rate than conventional synthetic polymer. Similarly in Suhaila (2007), a slight difference in the in the degradability rate between degradable and non-degradable polyethylene films was found after 90 days of soil burial test where degradable polyethylene is slightly higher. Other factors can also play a role in the degradability rate of the non-degradable plastic bag. Perhaps the presence of microorganisms in the garden soil medium increased the biodegradation process as what has been discussed in Singh & Sharma (2008).

As for the surface morphology analysis done via SEM, all of the plastic samples showed some changes formation of unevenness, roughness, cracks, holes and horizontal notches which are the results of degradation throughout the whole experiment duration of 120 days. Similarly, to the findings in Suhaila (2007) where all of the plastic samples made of degradable and non-degradable plastic samples showed physical changes such as rough surface and formation of cracks on hole. These physical and optical changes in the plastic bag samples are perhaps due to photodegradation and biodegradation that occur within the plastic sample as discussed in Singh & Sharma (2008).

In the FTIR analysis, most of the plastic samples showed increase in the peaks' intensities through the whole burial period. Suhaila (2007) also observed similar finding where new bands occurrence were identified in all of its plastic samples that indicate biodegradation process has taken place in the plastic samples. In this study, it was also observed that some plastic samples may have decrease in intensities after day 120 and this was observed on non-degradable plastic sample in landfill soil, oxo-degradable plastic sample in compost and oxo-degradable plastic sample in landfill soil. As discussed in Arutchelvi et al. (2008), the decrease is perhaps due to the decrease in the presence of certain bonds as a result of the utilization of oxidised polymers by the microorganisms.

Due to these positive results in degradation in all of the plastic samples in the soil burial test, it can be concluded that there is no significant difference in the degradation of all of the three (3) types of plastic sample or any significant difference in the burial medium factor on the degradation rate. No specific trend was observed to conclude one plastic sample has a better degradation rate in a certain burial medium as compared to another. Perhaps, with a longer burial period a better observation in the plastic sample degradation rate can be observed as plastic degradation takes a really long time to be completed.

Another objective of this study was to determine the awareness level of the public in Selangor on the "No Plastic Bag Campaign". In view of that it can be concluded that majority of the respondents in Selangor (91.2%) are aware of the existence of the "No Plastic Bag Campaign" with Malay ethnicity as the majority. The findings are similar to the studies done by Kamaruddin & Yusuf (2010) and Zen et al. (2013) where majority of the respondents have awareness on the "No Plastic Bag Campaign". Most may have heard about the campaign via broadcast media, published media and social media. The rest may have heard it through word of mouth by friends and family, print media, in school, college, university or shops. Ethnicity perhaps is due to social heritage and culture of the Malay community that make them more inclined to receive information on the "No Plastic Bag Campaign" in Malaysia as what similarly observed in Greenberg (2005). The current race proportion where 50.1% of Malaysian populations are Malays may also be the reason for such findings ("Malaysia demographics," 2016).

It was also found that the female respondents have more tendencies to receive information on the danger of plastic waste perhaps due to their inclination to understand environmental problems as supported by Zelezny et al. (2000) and Mohai (1992). This may have a connection with their role in family, community and workforce which makes them more susceptible to environmental impacts (Organization for Security and Co-operation in Europe, 2009). This is also consistent with the finding from Asmuni et al. (2015) which revealed women is the majority consumers who will bring plastic bag when shopping.

Although not all who have heard about the campaign have taken the initiative to reduce the usage of plastic bags, a majority of 76.5% have done so. Majority of 74.1% also responded positively to the discontinuation of plastic bag usage. In the research done by Kamaruddin & Yusuf (2010), majority of 66% feels comfortable with the campaign launch. It can be concluded that majority of the public are ready to stop the usage of plastic bag. However 73.8% of the respondents still discard 1 to 5 plastic bags every day due to the following reasons; plastic bags are easily available at the shops; plastic bags are provided for free by shops and retailers, durable, cheap and light in weight, and also lack of alternative materials.

In the Pearson correlation, 8.0% of the variance in the respondents' willingness to discontinue plastic bag usage is related to the respondents' level of education. This shows respondents' willingness to discontinue plastic bag usage is weakly correlated with their level of education. 60% of the public without higher education showed unwillingness to discontinue plastic bag usage. This is probably because they do not get enough exposure and understanding on the issue surrounding plastic waste. 50% who have higher education background are supportive towards the discontinuation of plastic bag usage. This is probably because they had more exposure on the issue surrounding plastic waste. The locality of the respondents also plays a role in the respondents habit in discarding plastic bags where respondent from Petaling, Klang and Ulu Selangor whom which 63% possessed at least a Bachelor's Degree are the majority who discarded the least plastic bag. Thus, it can be concluded that respondents with higher education background are more supportive with the discontinuation of plastic bag usage in Selangor. Zen et al. (2013) however have concluded the opposite in its research where positive reaction on the campaign was displayed by the respondents regardless of education background. Perhaps, it is because Zen et al. (2013) study was only focused on Shah Alam residents on the other hand this study includes all districts in Selangor.

Due to the insignificant difference in all plastic samples degradation rate, it is still not clear how degradable plastic bag will impact the environment in the long run. Perhaps the "No Plastic Bag Campaign" in Malaysia should reconsider selling degradable plastic bag and make it compulsory for all consumers to bring their own reusable bag in ensuring the effectiveness of the campaign. As majority of the respondents still discard at least 1 to 5 plastic bags in a day, it is crucial for the campaign to introduce a more effective alternative to plastic bag that is clearly proven to be less harmful to the environment. In the meantime, the effort to make every day as no plastic bag day can be expanded to other states to increase the impact of the campaign. The sale of degradable plastic bag perhaps can be replaced with reusable bag which is more durable and can be used for a longer period of time.

CHAPTER 5: CONCLUSION

5.1 Key Findings

In the determination of the degradability rates of selected types of plastic bags via soil burial test, no significant difference was found in the degradation of all of the three types of plastic sample as well as no significant difference in the burial medium factor on the degradation rate. This is similar to the results found in Suhaila (2007) where positive results were found on all plastic samples degradation however due to restricted burial time degradation pattern between different plastic samples were not significant.

Also, after estimation of the Selangor respondents' awareness level on the "No Plastic Bags Campaign", the study concludes that that majority of 91.2 % of the public in Selangor are aware of the existence of the "No Plastic Bag Campaign". Additionally, 60% of the respondents who are aware of the "No Plastic Bag Campaign" in Malaysia are Malays and 61% of the respondents who have received information on the danger of plastic wastes to the environment are female respondents. This can concluded that ethnicity and gender influence the awareness level of the respondents on the "No Plastic Bag Campaign" in Malaysia and the danger of plastic wastes to the environment, respectively.

Additionally, 74.1% of the public in Selangor are supportive towards the discontinuation of plastic bag usage and 76.5% have taken the initiative to reduce the usage of plastic bags. It can be concluded that majority of the public in Selangor are ready to discontinue the usage of plastic bag.

Finally, 50% of the public respondents in Selangor with higher education background showed willingness to discontinue plastic bag usage. On the other hand, 60% without higher education were not supportive to discontinue plastic bag usage.

Also, 85% respondents who tend to discard lesser plastic bags between 0 to 5 plastic bags daily are from Petaling, Ulu Selangor and Klang in which 63% of the residents possessed at least a Bachelor's Degree. Therefore, it can be concluded that respondents with higher education background are more willing to discontinue plastic bag usage in Selangor.

5.2 Policy Recommendations

In curbing the environmental issues caused by plastic bag waste, the alternative to the conventional plastic bag may not be degradable plastic bag as the long term benefit to the environment remains unclear. Due to this, the investment made by environmentally conscious public through purchasing degradable plastic bag at a higher price than non-degradable plastic bag may even go to waste. In this case, reusable bag seems more appropriate as it is meant for multiple used. Perhaps, the markets should stop selling degradable plastic bag in the market for RM 0.20 and only provide the consumer with an option to buy reusable bag. Reusable bag may be more expensive in the market; perhaps the government can subsidise reusable bag to family with lower income as part of the "No Plastic Bag Day" campaign to lessen the burden of the public. Perhaps this effort could be coupled with BR1M where the individuals and families who are entitled for it will be given free reusable bags as well. The amount of free reusable bags giveaway can be determined depending on the number of family members. Perhaps one to two reusable bags can be given out for free for eligible family per family member.

When the concern of burdening the public with the need to buy plastic bag or reusable bag is curbed by giving out free reusable bags to the lower income family, the "No Plastic Bag Day" could also be extended to everyday in different states other than

Selangor than Penang. This can be done in phases with a lot of emphasis on the impact of plastic waste to the environment and benefit of using reusable bag.

Additionally, the state government can customized their approach on the “No Plastic Bag Day” campaign based on different population needs as well as strategize it to be more targeted to a certain group of people that can make a bigger difference in the campaign. For example, a campaign targeting the women’s population can be organised as the study has found women to be more positively impacted by the campaign. The campaign can position woman as the change agents to spread the awareness on the danger of plastic bags and to encourage the use of reusable bag. Their role as mothers and the caretaker of the household would be beneficial in creating such influence.

5.3 Areas for Future Research

Generally, degradable plastic bag have higher degradability rate than non-degradable plastic bag. However, this research has found that is not the case. Even Suhaila (2007) only found a slight difference in the degradability rate of both materials. Perhaps further study on degradability rate and factors affecting the degradability should be carried out to understand the differences in degradability in both materials. Also, the fact that plastic bag is still being used widely for garbage disposal calls for a great need for such study.

As different types of plastic material contains different composition and degrades through different means, a study on plastic degradation of different plastic samples in its most ideal degradation condition can be done to identify the best plastic material to be introduced in the market. The research should include a study on the decomposed plastic debris impact to the environment. Another study to identify specific degrading microorganism as well as degradation enzymes in plastic degradation will also be beneficial to improve on the degradable plastic bag innovation.

Further study on the impact of socio-economic factor to awareness and behaviour on the “No Plastic Bag Day” campaign will be another interesting area of study that can be explored. As what was found in this study, socio-economic factor such as gender, race and educational background do have an impact on respondent’s awareness and behaviour. Such study will be beneficial for the state government to strategize the campaign by customizing the campaign approach to suit different population needs and to do a more targeted campaign as what has been proposed earlier.

The study on the effectiveness of the “No Plastic Bag Day” should be further continued with the introduction of everyday as “No Plastic Bag Day” by the Selangor state government in early 2017. The impact of the campaign might be different with the extension of days in the campaign.

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