CHAPTER TWO
REVIEW OF RELATED LITERATURE

This chapter reviews the literature in the following aspects:

(1) Concept of behavior

(2) Definitions of plastic

(3) Characteristics of plastic

(4) Plastic waste problems

(5) Plastic bag degradation

(6) Recycling

(7) Greenhouse effect and Global warming

(8) Climate change in Asia and Thailand

2.1 CONCEPT OF BEHAVIOR

Behavior consists of people's activities and actions, especially actions toward one another. As referred by Danielle M. Dick and Richard J. Rose in "Behavior Genetics: What's New? What's Next?" pages 70-74, many behavioral terms have meaning only in social comparisons: people identify others as contentious, courteous, or conscientious only by their actions in social contexts. The causes of individual differences in behavior remain a question in science and in everyday affairs. นิยะดา ชุณหะวงศ์ และนินนาท โอฬารวรวุฒิ, 2546, stated that behavior is the result of the selective response to certain activities. Such action is observable but may not be easy to notice and measure. Thus; certain instruments are needed to measure the behavior.

2.2 DEFINITIONS OF PLASTIC

Plastic is polymer substance acquired from chemical synthesis by taking monomer, the chemical compound of hydrocarbon in oil and natural gas, into a chemical synthesis process called "Polymerization". It will result in macromolecular plastic. The molecule of plastic mainly consists of carbon and hydrogen and some other elements such as oxygen, nitrogen, chlorine, fluorine, etc.

Swanson (1965) added that the Plastic Engineering Association and the Plastic Industry Council of the United States gave the definition of plastic as *"Plastic is the material which consist of many chemicals. The structure of a molecule of plastic is weighty but while in the production process, it will be deformed. Its production process will be made by heat or pressure or both."*

2.3 CHARACTERISTICS OF PLASTIC

2.3.1 Origins of Plastic

The purpose of the plastic invention is that, since the industrial revolution in Europe, there was a lack of natural resources especially iron which was being used widely in industries for making machines, tools, and many other equipments. Thus natural iron was scarce and this caused its price to rise rapidly. There was a need to find something else to use in place of iron which was insufficient and then came plastic.

เกษม พลายแก้ว, 2544, affirmed that plastic is a new kind of material which was recently invented about a hundred years ago when John and Isaiah Hyatt had invented the first type of plastic and entitled it as Celluloid or Cellulose nitrate. He used celluloid to make billiards balls instead of ivory because at that time ivory was scarce. Later, celluloid was used in making false gum and in 1882 the Eastman company used celluloid in making film. Not until 1909 did Dr. Leo Hendrik Baekeland discover a new type of plastic called "Phenol-Formaldehyde". This plastic was used in making pan handles, pots, and other electric equipment. This invention counted as the origin of the plastic industry revolution. Since then, plastic production technology has been developed many times over and resulted in many kinds of plastic with different attributes that can be used widely in human daily life. Therefore, we can say it is the age of plastic.

After plastic was invented, according to วสันต์ เอารัตน์, 2537, it could replace almost everything: metal, wood, glass, or tile, etc. Moreover, plastic could be produced in mass quantities and with the same quality and standard. As a result, plastic could satisfy industrial needs.

2.3.2 Types of plastic

Plastic can be classified by its production process into two categories:

1. Revertible plastic or Thermoplastic: The structure of the thermoplastic molecule is in a direct order or branch. This kind of plastic can be annealed by heat and will be solid again when it is cool. Thermoplastic can be reannealed and is recyclable. This kind of plastic includes Polyethylene: PE, Polypropylene: PP, Polyvinyl Chloride: PVC, Polystyrene: PS, Polyethylene Terephthalate: PET, etc.

2. Irrevertible plastic or Thermosetplastic: This kind of plastic is matured with heat or other means that make its chemical strings in the structure of molecular sticks so tight with each other that they cannot be reannealed or recycled. Thermoset plastic is heat and pressure proof at a high level so it is good at making products with high heat use and durable like melamine, polyurethane, and epoxy.

Each type of plastic has a different property from others so that they have different uses as shown in table 1.

Table1. Types and Properties of Plastic

Type of plastic	Property	Samples of Product
Polyethylene: PE	Lightweight, durable to pressure and stretch, scratch-proof, and hard chance fat permeability	Cold or hot plastic bag, drinking water bottle, artificial flower
Polypropylene: PP	Hard surface, lightweight, and electrical insulation	Enameled basin, straw
Polyvinyl Chloride: PVC	Transparent; durable to acid, alkali, and fat; easy to clean	Cooking oil bottle, PVC pipe, water pipe
Polystyrene : PS	Transparent; crisp; durable to light acid and alkali	Toothbrush and foam box

วินัย นุตมากุล, 2539, classified plastic by its means of use into 6 categories from most used to least used:

1. Packages, plastic bags, bottles and food containers, tools and equipment, and many appliances. Most of these products are made from polyethylene and polystyrene.

2. Products which are used in buildings and constructions like water pipes, gas pipes, flooring materials. Most of these products are made from polyvinyl chloride and melamine.

3. Consumables such as food containers, disposable medical products, toys, and sport equipment. Most of these products are made from polystyrene, polypropylene, and polyethylene.

4. Electric products and equipment such as electric appliances and communication equipment. Most of these products are made from polyvinyl chloride, polyethylene, polystyrene, and polypropylene.

5. Furniture and decorating equipment such as carpets and textiles. These products are made from polypropylene, polyvinyl chloride, and poly urethane.

6. Products which are used in car making, including car accessories. Most of them are made from poly urethane, polypropylene, and polyvinyl chloride.

2.4 PLASTIC WASTE PROBLEM

Plastic bags are usually single-use and will be disposed of as waste after being used. The National Metal and Materials Technology of Thailand say that 21% of each household's garbage is plastic and foam.

Plastic waste is a difficult problem in waste disposal and has become a symbol of a society called a throwaway society, indicated Harvey (1991). Since people litter plastic waste, there is plastic waste everywhere on the roads, beaches, and sewers. Littering plastic waste is a leading factor which causes environmental problems since it is difficult for plastic to biodegrade naturally. Thus, plastic waste remains in nature for decades and can blow or splash away easily due to its lightweight.

Plastic disposal also encounters problems in landfills. ดวงผา นิยมชัย , 2535, warned that garbage when being used in a landfill; if it consists of too much plastic waste, there might be a problem of land subsidence. This is because plastic is low in density; the ratio of its quantity and its weight ranges is a high rate and causes plastic waste to take up a lot of land space. Moreover, the shapes of plastic also make it difficult for plastic to gather in bulk with no space. As time goes by, it will subside one day. The solution to this problem is to cut or digest the plastic waste into small pieces before taking them to the landfill, however, it will greatly increase the cost of waste disposal. To bury or dump plastic waste into landfill site may also cause another problem; when it is washed or leashed by rain, it may pollute soil and underground water; and contaminate neighboring soil and water.

Another way of plastic disposal is to incinerate, วสันต์ เอารัตน์, 2537, but if the plastic waste is burnt with insufficient heat not to the point of absolute incineration, the smoke generated from such inefficient incineration will consist of poison gases. Inefficient incineration not only produces carbon dioxide and chlorofluorocarbons which will gather in the atmosphere and cause the greenhouse effect, but it also generates gases such as carbon monoxide, hydrogen chloride, formaldehyde, and nitrogen dioxide, which can be potentially harmful to the human body[1]. The level of virulence depends on the chemical substances of the plastic waste and density of gases. The incinerator which is designed properly must be able to burn at a high temperature of 1000-1200 degree Celsius and must have sufficient time to burn the gases' vapor for more than two seconds; and in any cases the waste or the generated gases must be incinerated immediately. Such a high-temp incinerator has a high price.

In the present time, there have been research papers and developments in order to dispose of plastic waste by inventing the plastic which is able to biodegrade in light or water. But these kinds of plastic may not be suitable for some purposes; such as, the plastic which is able to biodegrade in water might biodegrade more quickly than expected and may cause damage to the products. In addition, another problem is the

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[1] Toxicological Information Center, Ministry of Public Health, Thailand

substances added to plastic ingredients may cause more problems to the quality of soil and water.

2.5 PLASTIC BAG DEGRADATION

As stated above, plastic is a material which is widely used in every sector in the world due to its quality. The report of the Envis Centre on Environmental Information Systems, fully sponsored by the Ministry of Environment and Forests, the Government of India, says that millions of tonnes of plastic waste, including refuse sacks, carrier bags and packaging, are buried in landfill sites around the world each year[2]. China generates about 16 million tonnes, India 4.5 million tonnes and the UK 1 million tonnes, of which more than 800,000 tonnes is waste polyethylene, which is the material used for plastic bag production. Conventional polyethylene products can take longer than 100 years to degrade, using up valuable landfill space and potentially preventing the breakdown of biodegradable materials contained in such refuse sacks. Moreover, the managing director of Symphony Environmental Limited, U.K., Michael Laurier[3] affirmed that it can take up to 400 years for plastic to degrade. However, according to www.reusablebags.com, plastic bags can take up to 1,000 years to degrade in a landfill.

2.6 RECYCLING

Another way to reduce the use of new material is to put the used material into a process so that it can be used again. Porteous (1977) of the Open University Milton Keynes had categorized methods of recycling materials into 3 groups as follows:

1. Re-use Re-use is a means of bringing back the packages to use in the same manner and without changes in the shapes of the packages. This means can be proceeded by having the customers pay returnable deposits for the packages of

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[2] **Biodegradable Plastic**, Indian Centre for Plastics in the Environment (ICPE). (http://www.envis-icpe.com/biodegradable_polymers.htm)

[3] **Move to check plastic degradation**, the Hindu Paper, Feb 10, 2006

products. The customers can have their money back when they return such packages to the sellers. Or the customers can bring the empty packages back at the shop and refill them with the same products. This method is the easiest and the least energy consuming way of recycling.

2. Direct Recycling Direct recycling is a method of bringing back used materials into the reproduction process. The new products will be identical or similar to the old products. The reasons for using this method is the used products are no more in the original shape or form, or cracked or chipped. An example of the direct recycling is that broken glass bottle can be reproduced into a new glass bottle one. The recycled products made from used products by this means will have some poorer qualities than the virgin product due to a decrease in their purity.

3. Indirect Recycling Indirect recycling is a method of bringing back used materials into the reproduction process. The new products will be in different forms from the used products such as in the process of paving materials production made from fragments of glass bottles.

Hopfenbeck (1993) classified the recycling process into 4 categories:

1. Re-Use is the repetitive uses of products with the same original purpose of the products such as returnable bottles.

2. New Use is the use of the original products but for different purposes other than the original such as to clean juice bottles and use them as drinking water bottles.

3. Re-exploitation is the way of taking malformed or broken products or materials into the reproduction process. New products or materials retain in the same properties as they used to have.

4. New exploitation is to take products or materials into the reproduction process which changes them into new products or materials or make change in their original property such as to extract oil from plastic waste or to make paper boxes from pieces of paper.

Dr. Mark W. Meszaros (1991) divided the recycling process into 4 categories.

1. Primary recycling is the process of recycling used products and reproduces them into similar products such as to recycle aluminum cans into aluminum cans. This method is also called “closed loop recycling” or “true form of recycling”.

2. Secondary recycling is the method that takes used products into the process of reproduction. The new products will be different from the original products and come out with poorer physical and chemical properties, especially of paper and plastic products.

3. Tertiary recycling is to disintegrate or to split molecules of the products or materials into basic chemicals. This method is used with products or materials which are made from synthetic materials such as plastic.

4. Quaternary recycling is to make use of products or materials for their energy content such as to burn used materials and make use of the heat energy produced.

2.7 GREEN HOUSE EFFECT AND GLOBAL WARMING

For the past few years, climate change has become an issue drawing global attention like never seen before as the world has recently faced a number of unprecedented phenomena, including rapidly melting Arctic ice, huge forest fires, and unusual storms in many parts of the world. Recognition of its importance is seen by the awarding of the Nobel Prize for Peace recently to the Intergovernmental Panel on Climate Change or IPCC, and Al Gore. The number of global concerns has aroused awareness of the need to reduce the cause of the climate change. Noticeably, there are several campaigns highlighting the causes of global warming and the greenhouse effect; such as pollution released from factories, air-conditioners and cars, or over-consumption of plastic and plastic bags, and their effects that are more likely to occur in the near future. According to the UN Environment Program which issued its fourth Global Environment Outlook warning that there might not be enough water supply to the population in areas like India and China, if Himalayan glaciers shrink too much.

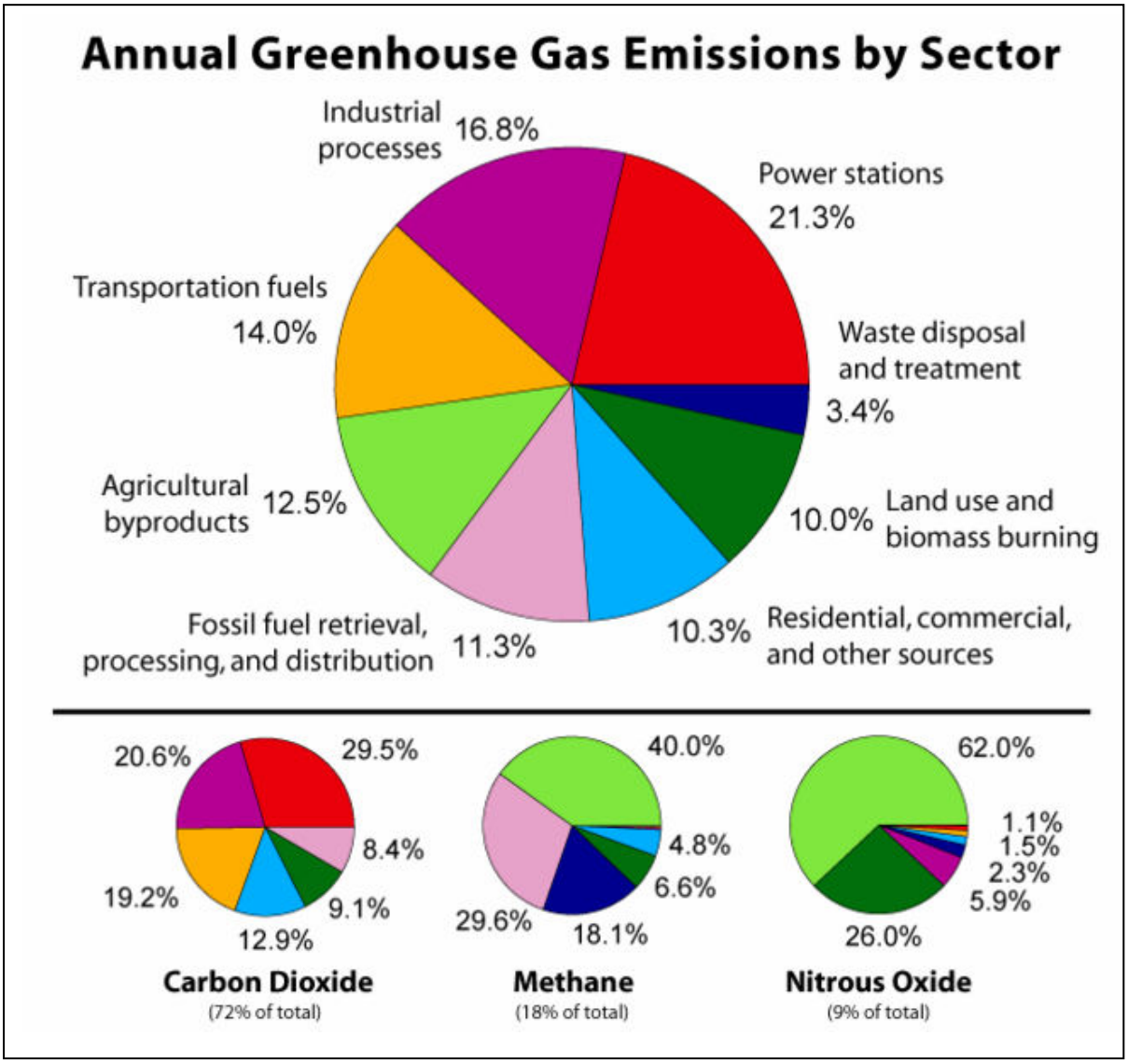
According to research on the Earth Guide[4] of the University of California, San Diego, the greenhouse effect and the global warming occurs when the Earth receives the radiation called electromagnetic radiation from the sun in the visible spectrum, with small amounts of infrared and ultraviolet. The incoming solar energy has a very

[4] http://earthguide.ucsd.edu/

short wave length and passes through the atmospheric gasses easily to reach the Earth's surface. The Earth's surface absorbs the solar energy and releases it back to the atmosphere as infrared radiation, some of which goes back into space. However, the infrared emitted by the Earth is absorbed by gasses in the atmosphere that re-emits the energy as heat back toward the Earth's surface. The main gases in the atmosphere that contribute to the greenhouse effect are water vapor, carbon dioxide, methane, and nitrous oxide. Other greenhouse gases include sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons and chlorofluorocarbons (CFC) which absorb the infrared radiation emitted by the Earth and reradiate the energy as heat back toward the Earth, causing a warming known as the greenhouse effect. The greenhouse effect has become severely exacerbated due to the increasing greenhouse gases emissions from human activities.

The United States' Environment Protection Agency (US EPA) provides sources of these green house gases, shown in ***Figure 1***, as stated below:

Figure 1: ***Annual greenhouse gas emission by sector, 2000***[5]



1. Carbon Dioxide (CO_2) is emitted to the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions e.g., manufacture of cement.

[5] Source: *http://en.wikipedia.org/wiki/Greenhouse_gas*

2. Methane (CH_4) is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in solid waste landfills.

3. Nitrous Oxide (N_2O) is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

4. Fluorinated Gases: Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for ozone-depleting substances i.e., CFCs, HCFCs, and halons. These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases (High GWP gases).

In relation to the abovementioned information, the greenhouse effect and global warming are mainly caused by human acts, including from things that people use in their everyday lives. Unfortunately, a rapid change in people's ways of living in the modern society has made them unaware of the effects caused by some electrical devices or products that help ease their lives such as waste gases from air conditioning units, gases from spray cans, pollution from cars and factories, etc. However, the occurrence of the greenhouse effect and global warming can also be prevented before it becomes too late by providing the right knowledge and stimulation to help prevent the serious consequences of the global effects to people around the world.

2.8 CLIMATE CHANGE IN ASIA AND THAILAND

As stated by H.E. Prof. Dr.Yongyuth Yuthavong, Minister of Science and Technology of Thailand, in an article on the http://www.nationmultimedia.com/2007, rapid population growth and development in several Asian countries will put additional pressures on natural ecosystems leading to a rapid rise in the release of greenhouse gases into the atmosphere.

So far, many Asian mountain glaciers may soon disappear, the permafrost is melting, extreme drought is happening in some countries. Glacial ice in the Tien Shan Mountains, China, has been reduced by one quarter in the past 40 years while the

central and eastern Himalayan glaciers in India is retreating by about 30 metres per year and may be all lost by 2035. Heat wave struck Andhra Pradesh state, Southern India, in May 2002 and resulted in the highest death toll on record. Moreover, coral reef bleaching has been found in many seas and oceans of Asia, including the Gulf of Thailand. The link between stronger El Nino events and cholera prevalence was also studied in Bangladesh and revealed the evidence that global warming over the last century is exacerbating human diseases.

Following the global alarms, Thai people are becoming increasingly aware of global warming. Additionally, with the occurrence of flash floods in Uttaradit, Sukhothai and Ayuthya, coral reef bleaching in the Andaman seas and unusual weather patterns elsewhere make Thais in both the governmental and private sectors more responsive to what has caused those unpredictable events and how to prevent them from happening.

In actual fact, Thailand has also been responsible for global greenhouse gas emissions although it is a medium-size country. It emits 1.13 percent, or about 67 million of 5.9 billion tonnes of carbon, of the world's net increase of atmospheric greenhouse gasses. In emissions per capita, Thailand produces 1.3 tonnes per head, slightly above the world average of 1.2 tonnes per capita. The amount of carbon dioxide emissions of Thailand could be explained by the rapid economic growth of the country. The GDP shares of Thailand's industrial and service sectors have grown at an accelerated rate. This economic growth has created a growing demand for fossil energy and hence higher emissions of carbon dioxide. Rough estimations indicate that a one percent increase in GDP may cause a roughly 0.9 percent increase in carbon dioxide emissions.

Moreover, the major sources of Thailand's greenhouse gas emissions arise from changing land-use patterns and from increased energy consumption. Deforestation for other use has led to a drastic drop in the amount of carbon stored in standing biomass and soils. The main source of greenhouse gas emissions is in energy conversion and consumption processes which produce a large amount of carbon dioxide. The consumption processes also include extreme number of plastic bags used throughout the nation. It is a normal practice that when shoppers buy food or any

products from shops or vendors, they can end up with many of plastic bags for each product. Most of the plastic bags end up in landfills, with only a few being recycled. According to the Bangkok Metropolitan Administration (BMA)'s data, 1800 tonnes of plastic bags (21 percent of all 8500 tonnes of garbage) are collected in Bangkok everyday. If the use of plastic bags is reduced, about one million tonnes of carbon dioxide emitted in Bangkok would be cut per year.

Concerning global warming and its effects, the Thai government seriously takes this issue into account. It has participated in many international forums such as "the United Nations Framework Convention on Climate Change (UNFCCC)", "the Vienna Convention for the Protection of the Ozone Layer", and "the Montreal Protocol on Substances that Deplete the Ozone Layer" (CFC control). In addition, the Thai government has conducted many campaigns and activities to raise the awareness of Thai people in an attempt to change their plastic consumption behavior to use cloth bags instead.