1. INTRODUCTION

1.1.Background

In the era of globalization, the development of food trade is growing very rapidly. In Indonesia, the modern markets or supermarkets have been established since the 1970s and focused on the large cities only. The development of modern market was keep going, until in 1977 a new concept of modern market came and known as a retail or mini market. The development of retail markets is generally oriented to provide comfort, security, and convenience toward consumers. Therefore the majority of retailers are located near residential areas (Natawidjaja, 2005).

One of the biggest retail markets in Indonesia is IR group, and nowadays (in mid-2018), the development of IR retail market has reached more than 15,000 stores spread across Indonesia. The stores do not only provide consumer goods, but also fresh food and beverage products, such as onigiri, bread, and coffee. In some urban areas, there are three classifications of IR, i.e, general IR, IH (hybrid IR), and IP (point IR). Both of IH and IP usually located in the city center, and provide larger variety of fresh food and directly processed food, such as grilled sausage, fresh baked bread, instant noodle, microwavable food, and beverages. Specifically for IP, they are also equipped with coffee shop inside the stores. In other words, IP tries to combine between retail businesses and simple cafes to satisfy consumer's convenience.

Based on data from search engine, i.e., Google (accessed on Septmber 2019), there were more than 90 IP and 92 IH stores spread across Indonesia in 2019. However, around 90% of the distribution of IPs and hybrids are more likely to be located on the Java. The development of fresh food or fresh processed food in retail industry cannot be separated from the used of plastic as a food container, packaging, and utensils (such as, spoon, knife, fork, and straw).

The role of plastic as food packaging will protect the food from any contaminations, and provided in a suitable size to avoid leftovers (Madival, Auras, Singh, & Narayan, 2009).The properties of plastic as a food packaging also determine the shelf life of food product and prevent food loss, such as in modified atmosphere packaging (MAP). Plastic also provide several public health benefits, such as PET bottles provide clean and hygiene mineral water supplies. (Andrady & Neal, 2009; Humbert, Rossi, Margni, Jolliet, & Loerincik, 2009). Moreover, food cutleris are needed by certain consumers who have special needs to access their food. However, the development of plastic design for food packaging will create environmental problem due to the generation of single use plastic waste, i.e., plastic which is use only one times and immediately discarded.

The significant increase in the amount of SUP waste has attracted the attention of several countries to reduce plastic and to endorse the use of environmentally friendly plastics.(Auras, Singh, & Singh, 2005; Dorgan, Lehermeier, Palade, 2001; Ramanathan, 2018). The safety and quality aspects of reusable plastic food container has been investigated to develop a quality assurance and decreased the total volume of plastic litter (Accorsi, Cascini, Cholette, Manzini, & Mora, 2014; Jetten & Kruijf, 2002). Several countries also tried to investigate the effect of paid plastic bags policy to reduce the total of single used plastic waste generation (Barnes, Chan-Halbrendt, Zhang, & Abejon, 2011; He, 2010; Khoiruman & Haryanto, 2017). Learning from the China paid plastic bag policy, it's caused 49% subtraction in the use of new plastic bags, but it also differs among regions, consumer groups, and shopping occasions. Temporary implementation of paid plastic bags in Surakarta (Indonesia), encourage several big retail's to provide more environmental plastic bags. Another investigation about consumer choices and willingness to pay for alternative (non-plastic) food containers, it's known that 66.49% consumer's expect packaging or alternative food container made from biodegradable ingredients (such as sugar cane waste), 88.94% that is microwavable, 100% water resistance, and 51.23% locally produced.

Currently, the generations of single use plastic waste from food sectors, such as in retail market is becoming a serious environmental problem due to its impact on the release of carbon gas emissions. Carbon is the most fundamental elements that makes up single use plastic. Its potential contribution to climate change can be estimated through its carbon footprint, i.e., an assessment to the total greenhouse gas (GHG) emissions of the polymer over its whole life cycle, and stated as CO_2 equivalent (Roibás, Rodríguez-garcía, Valdramidis, & Hospido, 2018). Carbon footprint is also an indicator to reduce the CO_2 emissions by changing the processes or activities to be more environmentally friendly to reduce the phenomenon of climate change. Climate change become a serious issues because it can cause an increase in earth's temperature, alteration in sea level that trigger flooding and drought risk, increase health problem, and etc (Akhtar, Sahibzada, & Saif, 2017).

The adverse effects of single use plastic waste are also related to the presence of microplastic, (Thompson et al., 2004). Indonesia is the second largest contributor in the world after China, to marine debris with the main component of plastic waste in various sizes (Jambeck, Roland Geyer, Chris Wilcox, 2015). From a total of 3,425 anthropogenic debris items found in the western North Pacific: around the Japanese archipelago, 33% of all debris items were plastic and 89% of the plastics items were single use plastic.

Nowadays, general waste management calculation in restaurant (include fast food restaurant) have been investigated by (Aarnio & Anne, 2008; Alfagi, Purnaweni, & Setiani, 2015; Ramanathan, 2018; Razza, Fieschi, Degli, & Bastioli, 2009; Singh, Kaushik, Soni, & Lamba, 2014), and waste management calculation in industry also have been investigated by (Girotto, Alibardi, & Cossu, 2015; Hyde, Smith, Smith, & Henningsson, 2001). However, there is no study that count the amount of single use plastic waste resulted from food service outlet in retail market. So, the aim of this study are estimate the total amount of single use plastic generated from the IR convenience store; to estimate the amount of single use plastic waste grouped by polymer types and food categories; to calculate the environmental burden of single use plastic waste expressed as carbon footprint; and, to explore and discuss the possibilities of product redesign in reducing the single use plastic waste based on food quality and safety aspects.

1.2.Literature Review

1.2.1. Plastics

Plastics are defined as a synthetic polymer, originated from the polymerization reaction of monomers extracted from gas or oil. Since the invention of the first modern plastic, several efficient and cheap manufacturing techniques have resulted in the mass production of inert, durable, corrosion resistant, and light weight plastics. Since the first of the 1940s, the amount of plastic being produced has increased rapidly, and reached 322 and 407 million tons of plastic being manufactured globally at the end of 2015 up to 2016 (Rabnawaz, Wyman, Auras, 2017). Unfortunately, around 4.8 to 12.7 million of metric tons plastic waste (5 to 10%) of the total plastics manufactured every year ends up in the ocean (Guven, Gokdağ, Jovanović, & Kıdeyş, 2017). The change in global production of plastic with the world population can be seen in Figure 1.

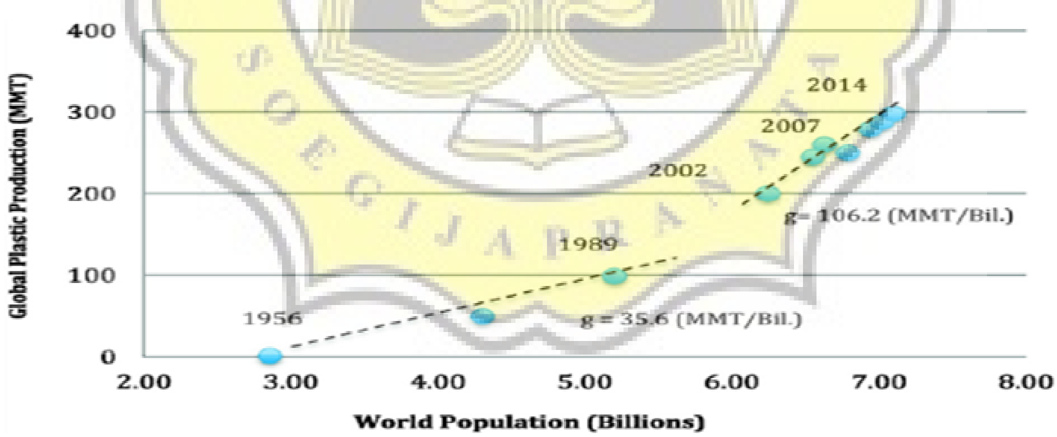

Figure 1. The Change Global Plastics Production (Andrady, 2017)

Polypropylene (PP) and polyethylene (PE), are thermoplastic polymers synthesis from polymerization reaction of propylene and ethylene, respectively and much used in food sectors, as a material for food packaging (Kao, 2012). Both of PP and PE was first discovered by Giulio Nata in 1954 and Reginald Gibson and Eric Fawcett in 1933, respectively. PP is the most widely applied as a single thermoplastic globally, and followed by PE, due to their cost-effective properties. In food industry PP plays a major role as a material for flexible barrier film pouches used for nuts, chips, and etc. Besides that, PP has also been used in blow molded bottles, such as in food trays, yoghurt cups, and margarine tub, glass replacement, film wrap for packaged food.

Thirty five million tons of PE resin manufactured, a half of PE is used as plastic film, and followed by 13.5% in blow and injection molded products. Typical products of PE are in variety blow molded containers, and some also use as film application (such as cling wrap, freezer and sandwich bags) (Andrady & Neal, 2009). In addition, there are several categories of PE based on their density, i.e., HDPE (0.945-0.965 g/cm^3), MDPE or medium density polyethylene (0.93-0.945 g/cm^3), LDPE (0.930-0.935 g/cm^3), LLDPE (0.925 g/cm^3). Both of PP and PE are odorless, acid and base resistant, and tasteless. Compared to PE, PP has better heat stable properties, and the general products of PP and PE are microwavable and dairy container, preserving boxes, wrapping films, and plastic bags (Andrady & Neal, 2009; Kao, 2012).

Polyethylene terephthalate (PET) is considered as a thermoplastic polymer resin. PET was first discovered by Dickson and Chemists Whinfield in 1941 and manufactured from the condensation reaction of ethylene glycol and terepthalic acid catalyzed by germanium or antimony compounds. Since it has excellent gas barrier properties, transparency, and toughness, PET is commonly used to manufacture plastic bottles particularly for wine, tea, juice, drinking water, and soft drink (Kao, 2012). Interestingly PET bottle almost has 100% transparency, lightweight, glossy, and resistance to CO_2 permeation. The usage of single use plastic PET bottle for carbonated soft drink will continue to increase 8% per annum (Andrady & Neal, 2009).

Polystyrene (PS) was first discovered by German Company (BASF) in 1930s. PS is synthesized from the reaction of benzene with ethylene oxide to create ethyl benzene, which is subsequently dehydrogenated to become styrene monomer, which will then be polymerized to create PS. There are 2 categories of PS, i.e., high impact grade (which the PS combined with polybutadiene), and general grade PS. Its affordability, combined with properties, such as excellent gas barrier properties, and high acid and alkaline tolerant, makes PS is widely used in the production of disposable tableware, such as plates, cups, instant noodle containers, lunch boxes, and bowls (Kao, 2012).

Polyvinyl chloride (PVC) was first manufactured by Eugen in 1872. PVC is a synthesis from the polymerization reaction of vinyl chloride monomers. PVC can be created softer and more flexible polymer by the addition of stabilizers and plasticizers to prevent from yellowing or deterioration, and to increase its transparency. In addition, because of their beneficial properties, such as low production cost, highly acid and base tolerant, transparent, higher gas barrier properties, it has been made into a large number of plastic products with different hardness based on the proportion of modulation. The general used of PVC are transparent boxes, wrapping films, and etc. (Kao, 2012). Based on Plastic Europe data, annual world demand for PVC is about 35 million tones, and 40% from that presents in Asia countries (Andrady & Neal, 2009)

Polycarbonate, is manufactured from transesterification reaction of diphenyl carbonate and bisphenol A or by the reaction of carbonyl dichloride (phosgene) and bisphenol A. polycarbonate is widely used to manufactured bottles, such as water and bottles for infant formula, due to their properties which are heat resistant, transparent, and impact resistant (Kao, 2012). The description of materials properties and there uses can be seen in Table 1 and Figure 2.

Tabel 1 The Description of Materials Properties and There Uses (Siddique, Khatib, & Kaur, 2008)

Type of Plastic	Properties	Some Uses
PET	Clear tough plastic, can be used as a fiber	Beverages bottles (soft drink and drinking water)
HDPE	Very general plastic, usually present in white or transparent, and colored	Milk and cream bottles, freezer bags, and shopping bags
UPVC	Hard, rigid, and clear plastic	Juice bottles
LDPE	Soft and flexible plastic	Black plastic sheet, and lids of ice cream containers
PP	Hard but sometimes also flexible, and many uses	Potato chips bag, ice cream cup, hinged lunch box
PS	Brittle and rigid plastic. Could be clear or glassy	Food plastics utensils and yoghurt container
EPS	Foamed, thermal insulation, energy absorbing, and light weight	Food container, hot drinking or beverage cup, food packaging, and meat trays

a. PET, polyethylene terepthalate; HDPE, high density polyethylene; UPVC, unplasticised poly vinyl chloride; LDPE, low density poly ethylene; PP, polypropylene; PS, polystyrene; EPS, Expanded polystyrene

Plastics

■ In your quest to go green, use this guide to use and sort plastic. The number, usually found with a triangle symbol on a container, indicates the type of resin used to produce the plastic. Call **1-800-CLEANUP** for recycling information in your state.

1 PETE

Number 1 • *PETE or PET (polyethylene terephthalate)*

IS USED IN .... microwavable food trays; salad dressing, soft drink, water, and beer bottles

STATUS .... hard to clean; absorbs bacteria and flavors; avoid reusing

IS RECYCLED TO MAKE . . carpet, furniture, new containers, Polar fleece

2 HDPE

Number 2 • *HDPE (high-density polyethylene)*

IS USED IN .... household cleaner and shampoo bottles, milk jugs, yogurt tubs

STATUS .... transmits no known chemicals into food

IS RECYCLED TO MAKE . . detergent bottles, fencing, floor tiles, pens

3 V

Number 3 • *V or PVC (vinyl)*

IS USED IN .... cooking oil bottles, clear food packaging, mouthwash bottles

STATUS .... is believed to contain phalates that interfere with hormonal development; avoid

IS RECYCLED TO MAKE . . cables, mudflaps, paneling, roadway gutters

4 LDPE

Number 4 • *LDPE (low-density polyethylene)*

IS USED IN .... bread and shopping bags, carpet, clothing, furniture

STATUS .... transmits no known chemicals into food

IS RECYCLED TO MAKE . . envelopes, floor tiles, lumber, trash-can liners

5 PP

Number 5 • *PP (polypropylene)*

IS USED IN .... ketchup bottles, medicine and syrup bottles, drinking straws

STATUS .... transmits no known chemicals into food

IS RECYCLED TO MAKE . . battery cables, brooms, ice scrapers, rakes

6 PS

Number 6 • *PS (polystyrene)*

IS USED IN .... disposable cups and plates, egg cartons, take-out containers

STATUS .... is believed to leach styrene, a possible human carcinogen, into food; avoid

IS RECYCLED TO MAKE . . foam packaging, insulation, light switchplates, rulers

7 OTHER

Number 7 • *Other (miscellaneous)*

IS USED IN .... 3- and 5-gallon water jugs, nylon, some food containers

STATUS .... contains bisphenol A, which has been linked to heart disease and obesity; avoid

IS RECYCLED TO MAKE . . custom-made products

Figure 2. The Description of Seven Types of Polymers and There Uses

1.2.2. Carbon Footprint

Carbon footprint (CF) is a measure of greenhouse gas (GHG) emissions associated with a product or activities. CF is also a methodology for measuring total GHG emissions (in CO_2 eq) from the product life cycle, starting from the raw material production to final disposal of finished products (excluding in-use emissions) (Roibás et al., 2018). CF represents the amount of CO_2 emitted either directly or indirectly through the combustion fossil fuels as a result of the generation of fossil energy to manufacture and deliver the products to reach the market.

CF is defined as a method of estimating total emissions of methane (CH_4) and carbon dioxide (CO_2) from a defined system, and population, taking into account all relevant sources, storage, and immersed in temporal and spatial population boundaries, activity or system of interests. CF is calculated as the carbon dioxide equivalent (CO2 eq) using the relevant 100-year global warming potential (GWP 100) (Akhtar et al., 2017). In the case of single use plastic, it is important to calculate CF to evaluate how much the consumer or retail market group contributes to the carbon emissions resulted from the use of each type polymer.

1.2.3. SUP and Environmental Problem

Since the early 1940s, when massive plastic production began, until 2015, it was estimated that more than 8.3 billion tons of plastic had been produced globally and 40% of it was produced as single-use plastic. However, it is predicted that only around 2.5 billion tons of plastic or about 30% of the total plastic production is still being used. More than three quarters (around 6.3 billion tons) has now become waste (Geyer, Jambeck, & Law, 2017; Waring, Harris, & Mitchell, 2018). Of this amount, around 0.8 billion tons or 12% of plastic was incinerated, 0.6 billion tons (9%) was recycled and only 10% was recycled twice or more. About 60% (4.9 billion tons) of all plastic that has ever been produced - disposed of and accumulated in nature or landfills (Figure 3) (Geyer et al., 2017).

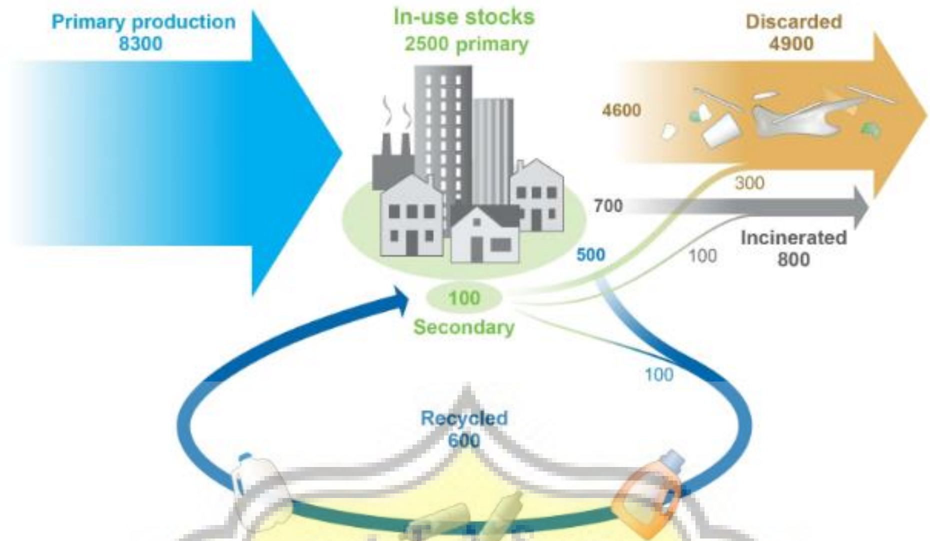

Figure 3. Global Plastic Production Life Cycle to End of Life (1940 to 2015; in Million Metric Tons) (Geyer et al., 2017)

Waste management in Indonesia is regulated in the constitution No. 18 of 2008, while in Semarang city is regulated in *Peraturan Daerah No. 6 tahun 2012*, i.e., all the cities or district governments should change the waste disposal system into a waste management system. The waste management system in the Jatibarang landfill (Semarang) was carried out using the sanitary landfill standard, which is a waste treatment system that treats old waste residues that have been buried for about one to two years in the Jatibarang landfill active area. Based on data in 2015, the population of Semarang cities was 1,595,267, generated landfill per day of 4,998.85 m^3, and which can be transported is only 4,349.00 m^3 per day or 1,587,385 m^3 per year. The waste that goes into the Jatibarang landfill, 65% will be processed and the rest will be processed by PT. Narpati and used as fertilizer (Pramadianto Farizqi and Nina Widowati, 2016).

Millions of tons of SUP waste produced every year can be physically damaging because plastic waste is potentially toxic and absorbs other pollutants. This Is due to plastic constituents, i.e., carbon which can eventually be emitted into the atmosphere as CO_2.

Thus, the global environmental problems of marine plastic waste pollution and climate change are naturally related (Lin & Nakamura, 2019). The UN Secretary General, Antonio Guterres stated that in 2018, the amount of sea debris, such as micro plastic has exceeded the number of stars in the Milky Way galaxy, and every year the number is predicted to increase 8 million tons. If these trends continue, in 2050 the amount of plastic waste in the ocean will be more numerous than fish (Filatov, Zaitseva, & Larionova, 2018).

Research on the adverse effects of plastic debris, especially microplastic (i.e.,any particle of plastics with approximately 20 μm in diameter, and later, the definition altered to all plastic particles which is < 5 mm in size) in marine and freshwater ecosystems has increased in recent years, but little evidence of the impact of micro plastic bioaccumulation and the wider impact on food webs remains unclear (Carbery, Connor, & Thavamani, 2018; Thompson et al., 2004). An understanding of the negative impacts on human health regarding consumption of micro plastic-containing organisms is limited and difficult to evaluate or lack of evidence (Gabriel et al., 2018). Other studies suggest that, micro plastic absorption through the digestive tract has been shown to have toxic effects, although not significant. However, the intake of nano plastic particles will be more easily absorbed and potentially accumulate in the liver, brain, and other tissues. The accumulation of nanoparticle components in very high exposure is at risk of disrupting the reproductive system and central nervous system (Waring et al., 2018). A complete description of the various plastic particle debris and their effects can be seen in Figure 4.

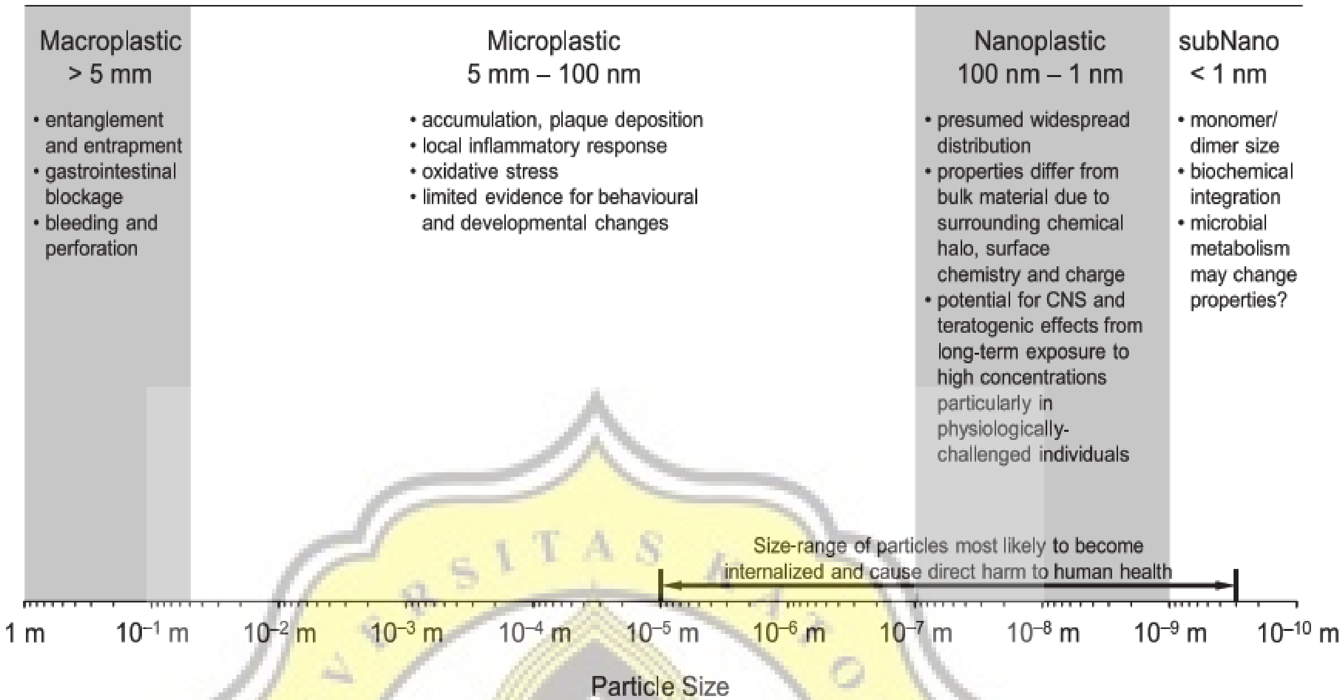

Figure 4. Description of Various Plastic Particles and Its Alleged Impact (Waring et al., 2018)

Other adverse effect of single-use plastic was reported in south Africa, related to the use of mineral water bottle. It was found that the storage of mineral water bottle at room temperature (20 and 40ºC) posed a risk of bisphenol-A (BPA) release, at higher temperatures the release of this toxic substance is faster (Aneck-hahn et al., 2018). The BPA was first discovered in the 1890s and is widely used in plastic products. A number of studies have positively revealed that the component has the potential to cause interference with the endocrine system, disturb cell viability, and increased generation or activation of DNA damage maker protein (Son, Nam, Kim, Chan, & Shin, 2018). Other studies also proved that, BPA can damage the reproductive system and inhibit prenatal or childhood development (Angela Balistrieri, Laura Hobohm, Trisha Srivastava, Angela Meier, 2018).

In addition to its toxicity, mismanaged plastics waste has also created aesthetic problem of the urban as well as rural landscapes in many developing countries, including Indonesia (Mahyudin, 2017). It is therefore important to find appropriate solution for reducing the plastic waste from the upstream, i.e., by reducing the single use plastic application in food related business. One way to deal with this issue is by introducing a better packaging design and materials.

1.3.Aim of the Research

The aims of this study are estimate the total amount of single use plastic generated from convenience stores; to estimate the amount of single use plastic waste grouped by polymer types and food categories; to calculate the environmental burden of single use plastic waste expressed as carbon footprint; and, to explore and discuss the possibilities of product redesign in reducing the single use plastic waste based on food quality and safety aspects.