سلسلةالإمدادالمستدامة:السيناريوهات المختلفة للتخلص من التأثيرالضار لصناعة البلاستيك على البيئة في المجتمع المصري

Sustainable Supply Chain: The Influence of Plastic Disposal Scenarios on the Society in Egypt

د/ يحيي حسن أحمد سليم
مدرس بكلية النقل الدولي واللوجستيات
الأكاديمية العربية للعلوم والتكنولوجيا
والنقل البحري، القاهرة – مصر
yehia_hassan@egypt.aast.edu

د/ وليد يوسف منتصر عوض
مدرس منتدب بكلية النقل الدولي واللوجستيات
الاكاديمية العربية للعلوم والتكنولوجيا والنقل
البحري، القاهرة - مصر
walidmontasser@gmail.com

مجلة الدراسات التجارية المعاصرة
كلية التجارة – جامعة كفر الشيخ
المجلد العاشر - العدد الثامن عشر - الجزء الثاني
يوليو 2024م
رابط المجلة : https://csj.journals.ekb.eg

ABSTRACT

A supply chain is a network that joins an organization to its suppliers in order to produce and distribute a specific products and/or services to the final consumers. This network includes a bundle of different activities that includes human resources, facilities, information, and resources. The supply chain network also represents the steps taken get the products and/or services from its original state right to the consumer. Logistics is a significant part of supply chain network; it composes of both forward logistics and reverse logistics. Forward logistics includes product introduction, procuring of materials, production, transportation to distribution centers, and delivery to the organization customer. While reverse logistics refer to the backward movement of products and materials through the supply chain post-delivery. Often, reverse logistics are linked with returns and recalls, but they also include recycling programs, product disposal, and asset recovery, Reverse logistics emerged as a result to the negative impact of moving materials, parts, components and supplies on the environment, and because of the need to properly manage them efficiently and effectively, this inverse flow has grown through the last decade due to rise of recycling initiatives and reuse of products. Businesses are increasingly recognizing the importance of sustainability and are taking steps to make their supply chains more sustainable. Recycling is a reverse logistics activity focusing on transforming waste materials to some new raw materials. The recycled products will be sent to the suppliers and enter the supply chain network again as a raw material for introducing new products, different types of materials could be subjected to recycling processes such as glass, paper, cardboard, metal, tires, textiles, batteries, and plastics. Plastics are inexpensive, lightweight and durable materials, which can readily be molded into a variety of products that find use in a wide range of applications. As a consequence, the production of plastics has increased intensively over the last 6 decades. However, current levels of their usage and disposal generate several environmental problems. Around 4 per cent of world oil and gas production, a non-renewable resource, is used as feedstock for plastics and a further 3–4% is expended to provide energy for their manufacture. A major portion of plastic produced each year is used to make disposable items of packaging or other short-lived products that are discarded within a year of manufacture. These two observations alone indicate that our current use of plastics is not sustainable. In addition, because of the durability of the polymers involved, substantial quantities of

discarded end-of-life plastics are accumulating as debris in landfills and in natural habitats worldwide. Recycling is one of the most important actions currently available to reduce these impacts and represents one of the most dynamic areas in the plastics industry today. Business.

Recycling provides opportunities to reduce oil usage, carbon dioxide emissions and the quantities of waste requiring disposal. The aim of this research was to discuss the challenges faces recycling initiatives in Egypt, and how Egyptian decision makers can overcome them, to achieve these objectives a structured interview was conducted with one of the officials of the ministry of environment as to know clearly and precisely the status of recycling initiatives conducted by the government to support sustainability efforts in Egypt, also an intensive literature review was conducted for collecting more information.

Key words: Sustainable Supply Chain, Supply Chain Management, Reverse Logistics, Plastic profile, Plastic recycling, Plastic recycling schemes**.**

ملخص البحث

سلسلة التوريد هي شبكة بين الشركة وموردیها لإنتاج وتوزيع منتج معين للمشتري النهائي. وتشمل هذه الشبكة أنشطة مختلفة وأشخاص وكيانات ومعلومات وموارد مختلفة. كما تمثل سلسلة التوريد الخطوات التي تتم للحصول على المنتج أو الخدمة من حالتها الأصلية إلى العميل.

اما اللوجستيات فهي عبارة عن مجموعة من الأنشطة التي تتم من خلال سلسلة الإمداد؛ و هي تتألف من اللوجستيات الأمامية واللوجستيات العكسية. وتشمل الخدمات اللوجستية المقدمة الاتي: تطوير المنتج، تصنيع المواد، النقل إلى مراكز التوزيع، وتسليم المنتج النهائي للمستهلك. بينما تعني اللوجستيات العكسية إلى نقل المنتجات والمواد مرة أخرى إلى سلسلة التوريد بعد التسليم.

وفي كثير من الأحيان، ترتبط الخدمات اللوجستية العكسية مع عمليات إعادة التدوير، ويمكن ايضا أن تشمل برامج إعادة التدوير، التخلص من المنتجات المعيبة او منتهية الصلاحيه، كذلك استعادة الأصول. وقد ظهرت اللوجستيات العكسية كإستجابة للأثر المتزايد لنقل المواد والأجزاء والمكونات واللوازم الإنتاجية علي البيئة، والحاجة إلى إدارتها بشكل سليم، وقد نما هذا التدفق العكسي خلال السنوات الأخيرة بسبب زيادة أنشطة إعادة التدوير وإعادة استخدام المنتجات والطرود. وتهتم كلا من الصناعات الإنتاجية والخدمية على نحو متزايد بأهمية الاستدامة وتتخذ خطوات لجعل سلاسل إمداداتها أكثر كفاءة و فاعلية.

ان إعادة التدوير هي احدي الانشطة المرتبطة باللوجستيات العكسية و من بين مهامها العمل على تحويل النفايات إلى مواد خام جديدة .حيث يتم إرسال المنتجات المعاد تدويرها إلى المورد الاصلي و الذي يقوم بادخالها الي سلسلة التوريد مرة أخرى كمادة خام صالحة لانتاج منتجات جديدة، وتشمل المواد القابلة لإعادة التدوير العديد من أنواع الزجاج، الورق، الكرتون، المعادن، الإطارات، المنسوجات، البطاريات، واللدائن.

واذا تحدثنا عن البلاستيك كاحد اهم المواد القابلة للتدوير فيمكن ا لقول بانها مادة رخيصة، خفيفة الوزن، ومتينة، ويمكن استخدامها بسهولة في انتاج مجموعة متنوعة من المنتجات التي بدورها يمكن استخدامها في مجموعة واسعة من التطبيقات. ونتيجة لهذا فقد ارتفع إنتاج البلاستيك بشكل ملحوظ على مدى السنوات الستين الماضية. مما ادي الي ظهور العديد من المشاكل البيئية. حيث ان انتاجة يستهلك حوالي 4 في المائة من الإنتاج العالمي للنفط والغاز، وهو مورد غير متجدد، ويستخدم جزء كبير من البلاستيك المنتج كل عام في صنع مواد التغليف التي تستخدم مرة واحدة أو غيرها من المنتجات قصيرة العمر التي يتم التخلص منها في غضون سنة من التصنيع، وبالإضافة إلى ذلك، وبسبب متانة البوليمرات و هي المادة التي تستخدم في تصنيعة، فإن كميات كبيرة من اللدائن المهلكة المتخلص منها تتراكم في شكل حطام في مدافن القمامة حول العالم.

لذلك فان إعادة التدوير هي واحدة من أهم الإجراءات المتاحة حاليا للحد من هذه التأثيرات، وتمثل واحدة من أكثر المجالات ديناميكية في صناعة البلاستيك اليوم .كما توفر إعادة التدوير فرصًا للحد من استخدام النفط وانبعاثات ثاني أكسيد الكربون وكميات النفايات التي تتطلب التخلص منها.

ان الهدف من هذا البحث هو مناقشة التحديات التي تواجه مبادرات إعادة التدوير في مصر، وكيف يمكن لصانعي القرار المصريين التغلب عليها، لتحقيق هذه الأهداف قام الباحثان باجراء

مقابلات شخصية مع احد المسئولين داخل وزارة البيئة المصرية ذلك للحصول علي معلومات اولية تخص صناعة البلاستيك في مصر و المشاكل المرتبطة بها، و مبادرات اعادة التدوير التي تتبناها الوزارة للتعامل مع هذة المشاكل و الحد من تأثيرها الضار علي البيئة و المجتمع، كما قاموا بمراجعة شاملة لكل مبادرات اعادة التدوير حول العالم للاستفادة منها في التجربة المصرية .

الكلمات الرئيسية: سلسلة الإمداد المستدامة، إدارة سلسلة الإمداد، الخدمات اللوجستية العكسية، صناعة البلاستيك، إعادة تدوير البلاستيك، خطط إعادة تدوير البلاستيك .

1. Introduction:

The usage of plastics has become vital in our daily lives. Plastics nearly appears in everything we use, so we take it for granted, for example plastics could be found in our clothes, pens, furniture's and is also used in wrapping the food we eat. So it is sometimes hard to believe that plastics have only been available only ten decades ago. Yet in this time plastic has affected deeply the quality of our lives. Plastics give us the possibility of manufacturing well-designed, beautiful products from the very many different types of plastics materials that are commonly available today. But unfortunately plastic has a noxious impact on environment, it's pervasive found everywhere not only in the streets but also water resources, plastic trashes is found in the bowels of about 85% of the world's sea birds, in the stomachs 60% of the world's sea turtles, and it's even throttling the life out of the aquatics, plastics are one of the main inputs of fracking, fracking harm the planet, it is so toxic for water, soil, and even air, it creates underground cavities that collapse into sinkholes, and it raises pressure in underground rock formations, destabilizing them and leading to earthquakes. Not all plastic could be recycled and not all available recyclable plastic is recycled, most plastics last forever, plastics survive even through the toughest conditions.

2. Literature Review:

2.1 Sustainable Supply Chain

Sustainable supply chain management (SSCM) refers to the intelligible and pellucid incorporation and fulfillment of organizations' social, environmental, and economic goals through the effective harmonizing of internal organizational processes (Ballou, R. H., Gilbert, S. M., & Mukherjee, A. ,2012). In 2013, the Supply Chain Management Professional Council updated the concept of sustainability as a business effort to comply to the elements of sustainable development, taking into account the requirements of stakeholders. To achieve sustainability, organizations need to redesign their current supply chain networks to merge its sustainability goals through their operations from acquisition to distribution. In describing the Sustainable supply chain SSC (Belhadji, O., & Oulamara, A., 2018), state that moving the product from the node with the highest value, in addition to economic justification, has major social and environmental ramifications. For example, road transport may lead to congestion and pollution. However, by compressing vehicle loads, congestion and pollution

can be reduced and a step towards Sustainability is achieved. Therefore, the steps taken to manage an SSC must be made in three key dimensions: economic, environmental, and social. SSCM is a complex and challenging undertaking, but it is essential for businesses that want to be sustainable in the long term. By taking steps to implement SSCM, organizations can reduce their environmental impact, improve their social responsibility, and create a more sustainable future (Bowersox, D. J., & Closs, D. J. ,2017).

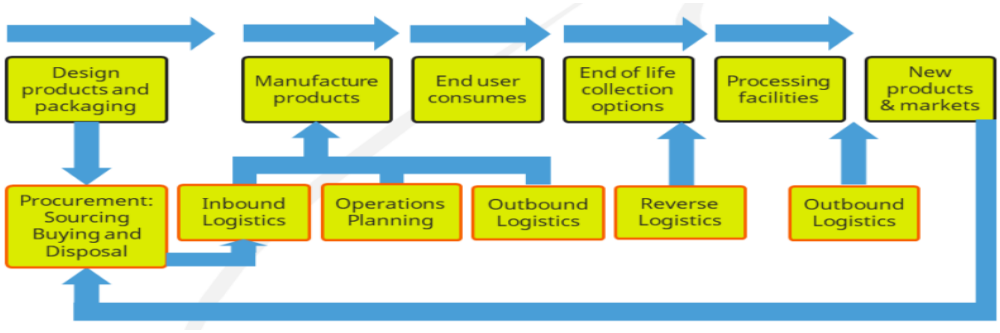

Figure 1: Sustainability in Supply Chain

Source: https://www.learnaboutlogistics.com/supply-networks-are-being-recognised-for-their-value/

2.1.1 Supply Chain Management

Supply chain management is dealing with the entire flow of products and/or services starting from procuring raw materials, converting them to finished goods, then deliver them to be sold to or traded with the organization customers (Christopher, M., & Rycroft, P. ,2021). A company creates a network of suppliers ("links" in the chain) that move the product along from the suppliers of raw materials to those organizations that deal directly with users. The supply chain can be divided into three main stages:

- **Planning:** This stage involves developing a plan for the flow of goods and services through the supply chain. This includes determining the demand for products, identifying suppliers, and negotiating contracts (Cooper, M. C., & Lee, H. L., 1997).
- **Execution:** This stage involves putting the plan into action. This includes ordering goods from suppliers, shipping goods to customers, and collecting payments (Cooper, M. C., & Lee, H. L., 1997).

- **Monitoring:** This stage involves tracking the performance of the supply chain and making adjustments as needed. This includes measuring

inventory levels, delivery times, and customer satisfaction (Cooper, M. C., & Lee, H. L., 1997).

Figure 2: Supply Chain Management

Source: Andiyappillai, N. (2020). Digital transformation in warehouse management systems (WMS) implementations. International Journal of Computer Applications, 177(45), 34-37.

2.1.2 Logistics Management

The terms supply chain management & logistics are often used interchangeably. Supply chain is a broader term that refers to the entire process of moving goods and services from the point of origin to the point of consumption, on the other hand logistics is different as it is a significant component of supply chain network. Logistics refers specifically to the part of the supply chain that deals with the planning, organizing and controlling the movement and storage of goods and/or services from their point of origin up to their final destination (Craighead, C. W., Handfield, R. B., & Nichols, E. L. ,2023).

Figure 3: Logistics Management

Source: https://marketbusinessnews.com/financial-glossary/logistics-definition-meaning/

Logistics is an umbrella that includes transportation activities, customer service activities, warehouses activities, sourcing activities, in addition to material handling activities. Logistics management begins with the acquisition of raw materials and ends with the delivery of the final produced goods and services. Successful logistics management ensures the delivery of the right product to the right place at the right shape in the right time. This will lead to a decrease in company's costs, increases in the level of customer satisfaction, increases in the amount of revenues and profits, and eventually will lead to a significant increase in market share. Logistics management is a complex and challenging task, but it is essential for businesses that want to be successful. By effectively managing their logistics, businesses can improve their efficiency, reduce their costs, and increase their customer satisfaction (Handfield, R. B., & Nichols, E. L. ,2019).

2.1.3 Differences between Forward & Reverse Logistics.

Forward and reverse logistics shares some key processes such as: planning, organizing, implementing, and controlling the efficient and effective flow of goods, information, either from the point of acquisition to the point of consumption, or the other way around. Even though origin and destination switch places, much is the same (Heizer, J. H., & Render, B. ,2023). However, in forward logistics the flow of goods is relatively

predictable. Businesses can typically forecast how much product they will need to move and when they will need to move it. While in reverse logistics, the flow of goods is much less predictable. Businesses cannot always forecast how many products will be returned or when they will be returned. This lack of predictability makes reverse logistics more challenging to manage than traditional logistics. Businesses need to be flexible and adaptable in order to respond to the changing demands of reverse logistics. But unpredictability is not the only challenge that faces reverse logistics, there is other challenges to handle such as cost, complexity, and regulations (Lambert, D. M., Stock, J. R., & Ellram, L. M. ,2022).

. But in spite of the challenges, reverse logistics is still an important part of a sustainable supply chain network. So through effective and efficient management of reverse logistics, businesses can reduce waste, conserve resources, and improve their environmental impact (Lee, H. L., & Billington, C. ,2012).

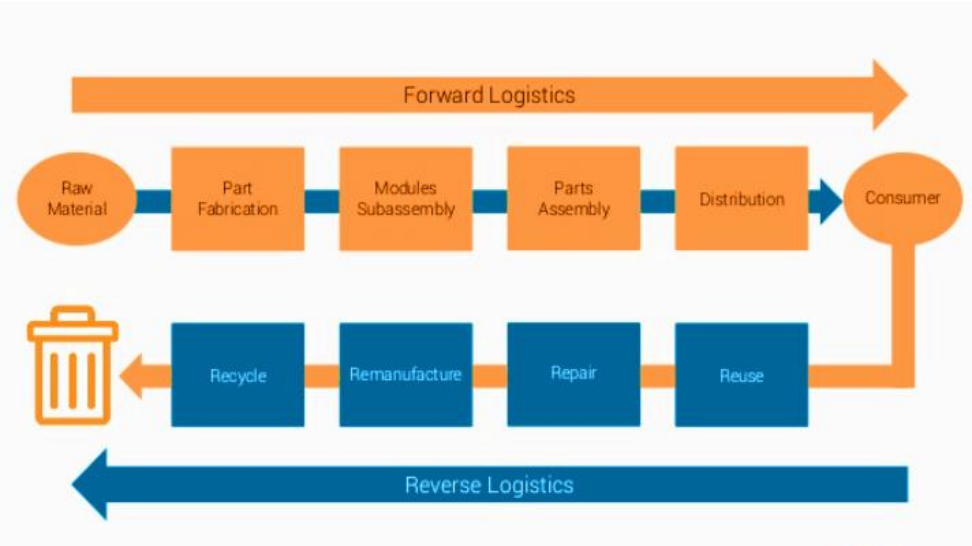

Figure 4: Differences between Forward and Reverse Logistics

Source: https://www.hartlogistic.com/japan-freight-forwarder

2.1.4 Reverse Logistics

Reverse Logistics are those used to manage the ‘backward’ movement of goods, from the consumer to the producer, or even back into raw materials through recycling Reverse logistics must be collective, through collecting used expired and even obsolete product from different destination

and moving them back to one or more manufacturing sites. The pace of the reverse logistics process is entirely based on supply; the lack of product returns can make the logistics stop entirely. A drawback in reverse logistics that the value of the returned product going back declines at each stage as costs rise due to the added materials handling requirements (Dekker, R., Fleischmann, M., Inderfurth, K., & Van Wassenhove, L. N. ,2016).

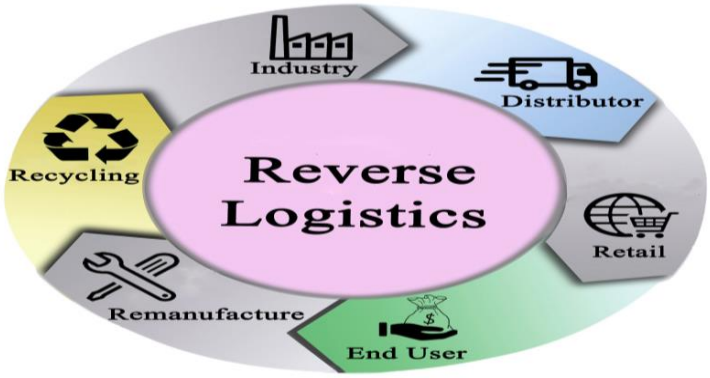

Figure 5: Reverse Logistics.

Source:https://www.sccgltd.com/featured-articles/the-environmental-impact-of-ecommerce-product-returns/

2.1.5 Types of Recovery Processes in Reverse Logistics

Due to limited landfill capacity, waste disposal become a major concern among businesses. In addition, customers are expecting that organization to introduce a green product to minimize the environmental pollution as much as possible. Product recovery is the process of collecting, transporting, and processing used products so that they can be reused, recycled, or disposed of in an environmentally friendly way (Rogers, D. S., & Tibben-Lembke, R. S., 2001). This can be done through a variety of channels, such as drop-off centers, mail-back programs, and reverse vending machines. Product recovery can be beneficial for both businesses and the environment. For businesses, it can help to reduce costs, improve their environmental image, and comply with regulations. For the environment, it can help to reduce waste, conserve resources, and prevent pollution. At the processing cite, the recovery decision of the returned products is very crucial as it will be sent back to the facility after the product is recovered. In some cases, it may be

more economical to dispose of returned products. However, in other cases, it may be more beneficial to recover them. Ultimately, the decision of whether or not to recover returned products should be based on a careful assessment of all of the relevant factors (Savaskan, R. C., Bhattacharya, S., & Van Wassenhove, L. N. ,2004).

Repair: Repair is the simplest and least expensive method of recovery. It involves fixing a product that is broken or damaged. The repair process may involve replacing parts, adjusting settings, or cleaning the product (Seuring, S., & Müller, E. ,2008).

Refurbish: Refurbishing is more expensive than repair, but it can produce a product that is almost as good as new. The refurbishing process may involve disassembling the product, cleaning and inspecting all of the parts, and replacing any damaged or worn parts (Srivastava, S. K. ,2007).

Reuse: Reusing a product is the simplest and least expensive method of recovery. It is only possible for products that are still in good condition. Reused products can be sold or donated to charity (Rogers, D. S., 2001).

Remanufacture: Remanufacturing is the most expensive method of recovery, but it can produce a product that is as good as new. The remanufacturing process involves disassembling the product, cleaning and inspecting all of the parts, replacing any damaged or worn parts, and rebuilding the product (Savaskan, R. C., et al. ,2004).

Recycle: Recycling is a process of converting waste material to a new raw material. The recycled products will be sent to the supplier and enter the supply chain again as a raw material for new products. The purpose of recycling is to reuse the material from the returned product that is cannot be remanufactured or repaired. In order to reduce the cost of raw material, recycling could be the best alternative (Lieder, M., & Rashid, A. ,2016). This process can reduce the environmental impact and it is a good alternative to save the material from been disposed Recyclable materials include many kinds of glass, paper, cardboard, metal, plastic, tires, textiles, batteries, and electronics. The composting or other reuse of biodegradable waste such as food or garden waste is also a form of recycling. Materials to be recycled are either delivered to a household recycling center or picked up from curbside bins, then sorted, cleaned, and reprocessed into new materials destined for manufacturing new products.

2.1.6 The importance of recycling:

For centuries man has struggled hard to make things easier. Recycling is one of the multiple ways that makes life on earth worth living. Recycling is a methodology where wastes are processed and then put to reuse instead of thrown away. Recycling is a kind of mercy that nature has ever had on our environment. Without it, the world would've been a center of pollution and epidemics, and there will be time in the near future, where there will be no safe place on earth to live in. But now when industrialization has brought to the environment mess and pollutants, it has also acquired ways to recycle which in turn have controlled the pollution caused by the industries.

2.1.7 Types of Recycled Items:

Recycling paper is vital to ensure you reduce your environmental impact and reduce general waste, also there is metal recycling, electronic devices recycling. wood recycling, glass recycling, clothing and textile recycling, bricks and inert waste recycling, and last but not least is plastic recycling.

Figure 6: Types of Recycled Items

Source: https://www.dreamstime.com/stock-illustration-recycling-bins-around-recycling-sign-isolated-illustration-symbol-paper-plastic-glass-metal-mixed-separation-image50169883

3. Plastic Profile

Plastics give us the opportunity of introducing well-designed products from an enormous types of plastics materials that are currently available. The rapid development of manufacturing technology in the past ten decades have led to very high degree of a sophisticated technological understanding of plastics, that enable us to make and shape them in multiple ways (Al-Salem, M., Lettieri, M., Puglia, D., & Zuidema, H. ,2021). Plastic is currently used in almost every industry today. Plastics are found for example in the following products; packaging, buildings, transportation means, medical equipment's, furniture, IT devices, gadgets, electronics, and even toys. We claim to offer endless possibilities with plastic profiles, and we believe we are right. A plastic profile is a plastic component which is produced in an extrusion process (Crawford, R. J., & Crawford, B. ,2012).

3.1 Types of Plastic:

Plastics can be divided into four main categories: natural plastics, semi-synthetic plastics, thermoplastics, and thermosetting plastics

Natural plastics are materials that are naturally occurring and can be shaped and molded by heat. An example of this is amber, which is a form of fossilized pine tree resin (Kutz, M. ,2016).

Semi-synthetic plastics are made from naturally occurring materials that have been modified or changed by mixing them with other materials. An example of this is cellulose acetate, which is a reaction of cellulose fiber and acetic acid (Kutz, M. ,2016).

Synthetic plastics are materials that are derived from breaking down, or "cracking," carbon-based materials, such as crude oil, coal, or gas. This process changes the molecular structure of the material. Synthetic plastics are the most common type of plastic and are used in a wide variety of applications (Osswald, T. A., & Menges, G. ,2013).

Thermoplastics are plastics that can be softened and formed using heat. When they cool, they will take up the shape that they have been formed into. However, if heat is reapplied, they will soften again. Examples of thermoplastics are acrylic and styrene

Thermosetting plastics are plastics that soften when heated and can be molded when soft. When they cool, they will set into the molded shape. However, if heat is reapplied, they will not soften again. They are

permanently in the shape that they have been molded into. Examples of thermosetting plastics are polyester resins and melamine formaldehyde (Xanthos, M., & Xanthos, F. ,2014).

3.2 The Plastic Economy

Plastic is a material that is made from oil or natural gas. It is a major part of the petrochemical industry, which uses about 20% of the world's oil (Ellen MacArthur Foundation. ,2016). The main producers of plastic have historically been oil companies and chemical companies. The plastic industry is a capital-intensive business that is subject to market volatility. The main uses for plastic are packaging, building and construction, textiles, consumer goods, the automotive sector, and electronics. Plastics are an integral part of our everyday lives. For example, a UN report estimated that 500 billion plastic bags are used each year, which is 10 million every minute (Geyer, R., Jambeck, J. R., Law, K. L., Neal, J. R., Plastiche, J. M., Roland, R., ... & Van Wassenhove, L. N. ,2017). One of the characteristics of plastic is that it has a very short lifespan. It is often used only once and then thrown away. This is especially true for plastic packaging. According to a study by Roland Geyer at the University of California, of the 8.3 billion metric tons of plastic produced since 1950, 5.8 billion tons have been thrown away (Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., & Law, K. L. ,2015). Of that amount, only 500,000 metric tons have been recycled and 700 metric tons have been incinerated. The remaining 4.6 billion metric tons are still in the environment, mostly in the oceans (Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. ,2018).

The large amount of plastic waste in the environment is a major environmental problem. Plastic can take hundreds of years to break down, and it can harm wildlife and pollute our oceans.

3.3 Plastic as a Core Polemic

Plastic pollution is a major problem for society. It can contribute to climate change, pollute our drinking water, and harm human health. The production and incineration of plastic releases greenhouse gases into the atmosphere. A 2019 report found that these emissions could reach 260 billion tons by 2100, which is more than half of the earth's remaining carbon budget. Plastic pollution can also contaminate our drinking water. A 2017 study found that 83% of tap water samples taken around the world

contained plastic pollutants (Hope, K. ,2021). The United States had the highest contamination rate, followed by Lebanon and India. The chemicals used in plastic production can also be harmful to human health. Some of these chemicals can cause dermatitis upon contact with human skin. Children and women during their reproduction age are at most at risk and more prone to damaging their immune as well as their reproductive system from these hormone-disrupting chemicals. In addition to the environmental and health problems, plastic pollution can also be an eyesore that interferes with our enjoyment of the natural environment.

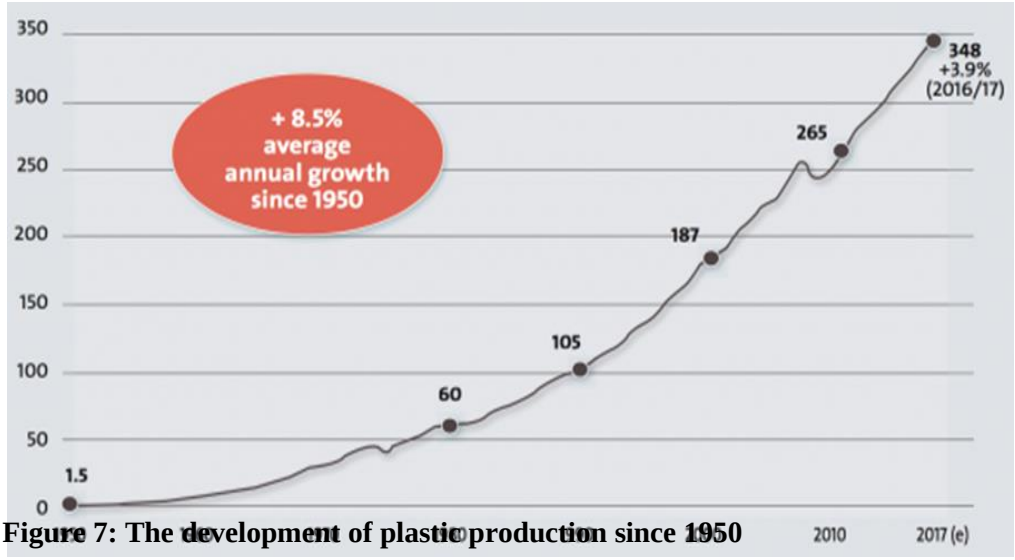

Figure 7: The development of plastic production since 1950

Source: Chalmin, P. (2019). The history of plastics: from the Capitol to the Tarpeian Rock. Field actions science reports. The Journal of Field Actions, (Special Issue 19), 6-11.

3.4 Plastic Disposal Scenarios

A plastic disposal scenario is a description of how plastic waste is managed after it is no longer needed. There are many different plastic disposal scenarios, but some of the most common ones include:

- Landfilling: This is the most common method of plastic disposal. Plastic waste is buried in landfills, where it can take hundreds of years to decompose.
- Incineration: This is a process of burning plastic waste to generate heat or electricity. However, incineration can release harmful pollutants into the air.

- Recycling: This is the process of converting plastic waste into new products. Recycling is a more sustainable option than landfilling or incineration. but it is not always possible to recycle all types of plastic (Adhikari, D., De Clercq, B., & Van Acker, K. ,2019).
- Upcycling: This is the process of transforming plastic waste into new products with a higher value than the original product. Upcycling is a more creative and sustainable option than recycling, but it is not as common.
- Reducing: This is the process of reducing the amount of plastic waste that is generated in the first place. This can be done by using less plastic, choosing reusable products, and repairing broken items instead of throwing them away (McKinsey & Company. ,2016).

The best plastic disposal scenario for a particular situation will depend on a number of factors, such as the type of plastic waste, the availability of resources, and the environmental impact of the different options.

3.5 Plastic Recycling

Recycling is one of the most important actions currently available to reduce the negative impacts of plastics wastes, and represents one of the most dynamic areas in the plastics industry today. Recycling provides opportunities to reduce oil usage, carbon dioxide emissions and the quantities of waste requiring disposal (Albini, A., Baroni, A., Di Virgilio, A.,

Lorenzetti, C., & Proietti, F. ,2023).

Figure 8: The Plastic Recycling Process

Source: https://www.istockphoto.com/illustrations/plastic-granules

4.1 Plastics industry in Egypt:

The plastics industry in Egypt is growing rapidly, in 2004, the country consumed about 1.2 million tons of plastic materials and resins worth $1.65 billion, and this demand is expected to grow by 10% annually for the next 5 years (Egyptian Plastics Federation. ,2023). The plastics industry in Egypt is divided into two main sectors: the production of raw materials and the production of finished products (El-Sayed, A. M., & Ebaid, A. G. ,2022). The raw materials sector is dominated by imports, with 65% of the market being supplied by foreign producers, the main suppliers are Korea, India, Russia, and the Gulf States, while the finished products sector is more diversified, with a mix of domestic and imported products. Polyethylene, polyvinyl chloride suspension, PET, and thermoset plastics are the most common locally manufactured products (Hegazy, M. M. ,2022). A private company now produces polypropylene, but most propylene continues to be imported. The Egyptian government is encouraging the growth of the plastics industry by providing incentives for local production and exports and as a result, the industry is expected to continue to grow in the coming years (Ibrahim, A. A., & El-Sayed, A. M. ,2023).

Table 1: Egypt's Plastic Market Supply

Sector	Working factories
Raw Materials	11
Electric parts, hoses, wire cables& pipes	100
Automotive	5
Building/Construction	18
Packing/Packaging	45
Woven Bags & Ropes	220
Agricultural	35
Furniture & House wear	230

Sector	Working factories
Stationary	35
Plastic and Acrylic Sheets	15
Machinery for dyes Manufacturing	8
Sanitary plastic ware, fittings, Poultry water tray	105
Clothing & Footwear	85
Artificial Leather	11
Miscellaneous	350
Total	**1273**

Source: Hegazy, M. M. (2022). The state of the art of plastic waste management in Egypt. In Plastic Waste Management (pp. 225-242). Springer Nature.

4.2 Overview of the Plastic Pollution Problem in Egypt.

Egypt is experiencing a severe plastic pollution problem. The country produces an estimated 3 million tons of plastic waste each year, but only about 5% of this waste is recycled (Abd El-Wahab, I. M., & El-Raey, M. A. ,2022). The remaining 95% ends up in landfills, illegal dumping sites, or waterways. Plastic pollution is a major environmental problem that can harm wildlife, pollute water supplies, and contribute to climate change (Soliman, N. F., El-Gammal, S. S., & El-Gendi, M. A. ,2022). In Egypt, plastic pollution is particularly harmful to the Nile River and the Mediterranean Sea. The Nile River is a vital source of water for Egypt, but it is also a major source of plastic pollution. A study by the World Wildlife Fund found that the Nile River is home to more than 1,000 species of fish, birds, and other animals, many of which are threatened by plastic pollution (Al-Salem, M., Lettieri, M., Puglia, D., & Zuidema, H., 2022).

The Mediterranean Sea is also a major victim of plastic pollution. Egypt is one of the top contributors of plastic pollution to the Mediterranean Sea, which is home to over 17,000 marine species.

4.2 Plastic Recycling in Egypt

Egypt's waste output is 16.2 million tons, of which plastic represents six percent, according to the Egyptian Plastic Technology Center that is affiliated with the Ministry of Trade and Industry. That's the equivalent of 970,000 tons of plastic waste, of which 45 percent is recycled and only five percent reused. About 50 percent of plastic garbage are not sorted out and instead are incinerated, which is harmful to the environment. Another report presented by (Ministry of Trade and Industry, 2016) revealed that the total annual plastic waste generation in Egypt has increased by more than 36% since 2000. Less than 60% of the generated waste is operated by public and private sectors. The rest accumulates on streets and illegal dumping sites, which indicates that the management system is mostly inefficient.

5. Research Methodology

This part of the research was conducted through three stages as follows:

- ***Stage one:*** A structured interview of five questions was conducted with The advisor to the minister of environment for waste management affaires.

Q1: What is your opinion about the current state of solid waste management as a whole in Egypt?

A1: The solid waste management is dispersed among more than one structure/ministry that lack the vision of cooperation and planning, as each ministry or structure approaches every management process separately.

Q2: Was there any efforts done by the Egyptian government to deal effectively with this dilemma?

A2: The Egyptian government commenced several initiatives to develop the waste management sector by the beginning of the new millennium, the actual efforts resulted in very little improvement.

Q3: What are the main problems that hinders plastic recycling efforts in Egypt?

A3: The main problems can be identified as following:

- The lack of effective legislations.
- The existence of an inefficient and incoherent legal framework.
- In addition to the limited funds and the inability of municipal authorities to provide reliable services cost-efficiently.

- The issue of public awareness and citizen behavior toward solid waste management in general and plastic recycling in particular was not addressed properly by the authorities.

Q4: What are the consequences that result from the deficiencies in the recycling processes?

A4: The situation is causing serious environmental problems. In fact, shortage in recycling processes has led to improper disposal of plastic wastes in waterways and drains causing a serious contamination in water supplies, which compromises Egypt's natural resources and public health.

Q5: What are your comments about the situation of waste management processes in Egypt?

A5: The respondent summarized his points of view as follows:

- Egyptian decision makers should be sober in adopting solutions.
- Climate change and the loss of biodiversity remain our top environmental concerns, and they cannot afford to adopt plastic alternatives that increase, not decrease, our impact on the planet.
- A cotton tote bag or steel water bottle may generate higher carbon emissions over its lifetime.
- A rush to bio-derived plastics may, as with bio-fuels, increase land cleared for crops.
- Plastics that degrade faster risk increasing the scourge of micro plastic in the environment if not partnered with better waste management.
- Some solutions to reduce plastic pollution are specific actions, policy makers can take to improve waste management, promote eco-friendly alternatives, educate consumers, enable voluntary reduction strategies and successfully implement bans or levies on the use and sale plastics.

➢ ***Stage Two:*** A search was conducted to study the best Recycling Schemes around the world, in order to identify the best solutions for recycling dilemma in Egypt.

Plastic Recycling Scheme in Norway: Norway has a very successful plastic bottle recycling scheme. The scheme charges consumers a small fee when they buy a plastic bottle, which they can then redeem by returning the bottle to a reverse vending machine or a shop. The government also puts an environmental tax on plastic producers, which

is reduced if the recycling rate is high. These measures have helped Norway to recycle 97% of its plastic bottles, with less than 1% ending up in the environment. The Norwegian model is based on a loan scheme. When a consumer buys a plastic bottle, they are essentially borrowing the bottle from the government (Haugland, H., & Skjærseth, J. B. ,2022). They can then return the bottle and get their money back. This system has been successful because it provides a financial incentive for consumers to recycle. The Norwegian government is also targeting plastic producers. By putting an environmental tax on plastic producers, the government is encouraging them to produce recyclable bottles. This tax is reduced if the recycling rate is high, so producers have a financial incentive to improve their recycling rates (Aadland, D., & Vatn, A. ,2020).

Plastic Recycling Scheme Germany: Germany is often seen as a recycling champion, but it actually recycles less plastic packaging waste than many people think. This is a problem because plastic pollution is a major environmental issue. Germany has a well-established recycling system, with separate bins for paper, biodegradables, plastic, and other waste. Germans are also used to returning their deposit bottles to the supermarket. Additionally, Germans return their deposit bottles to the supermarket, and drop glass bottles at public collecting points. Germans are boastful of their recycling network. Even children's note books praise the story of the colored bins. Indeed, the country is renowned as a world championship in recycling (Huber, S., & Schmiedchen, G. ,2022). When Germany introduced its recycling model with the "green dot" as a symbol in 1991, it was unique. Today, more than 25 countries have adopted the green-dot template, where companies pay a fee to finance the collection, sorting and recovery of packaging waste. In 2017, the World Economic Forum named the Germany as the world champion in recycling (German Environment Agency. ,2023).

Plastic Recycling Scheme in Austria: Austria has a recycling rate of 53.8%, which put it in the is second place after Norway in Europe. The Austrian government has banned any product that has a total organic carbon emission rate of more than 5% from going to landfill **(**Austrian Ministry for Sustainability and Tourism**.** ,2023). This effectively prevents any packaging from ending up in the ground. Austria adopts a producer responsibility model, which means that businesses are responsible for the waste that their products generate. This model is similar to the one used in Germany. The most well-known company that operates this

model in Austria is called (ARA) which is a 3 letters acronym for Altstoff Recycling Austria. ARA was founded in 1993 and is responsible for the waste management of companies that pay for the firm. ARA believes in the circular economy, and seeks to build a culture that supports environment protection through educating young people about the importance of recycling, using for example teaching materials, including comics and coloring books (Brunner, P. H., & Rechberger, H. ,2017).

Plastic Recycling Scheme in South Korea South Korea is the only non-European country in the top five for recycling rates. South Korea has a recycling rate of 53.7%, which is the highest of any non-European country. The country has enjoyed success with its recycling system, which is based on privately-run companies that collect the waste and sell it on for profit. However, this system is facing challenges due to China's ban on the import of plastic waste. China was the biggest buyer of Korean plastic waste, and the ban has made it more difficult for Korean businesses to make money from recycling. This has led to staff lay-offs and plastic waste starting to pile up on the streets. The South Korean government has responded by providing financial help to the recycling companies. The government has also implemented policies to reduce plastic waste, including banning colored plastic bottles and PVC by 2020, and phasing out disposable cups and plastic screws by 2027. These policies are a step in the right direction, but more needs to be done to address the plastic waste crisis in South Korea. The country needs to change its ways of production, consumption, recycling, and even its culture (Kim, J. H., & Park, H. S., 2023).

Plastic Recycling Scheme in Switzerland: Switzerland has a recycling rate of 49.7%, which is one of the highest in the world. This is due to a number of factors, including a "polluter pays" policy, a tax on landfill waste, and a well-established recycling infrastructure. The polluter pays policy means that households and businesses pay for any non-recyclable waste they produce (Swiss Federal Office for the Environment. ,2023). This encourages people to recycle, as they have to pay for the waste that they do not recycle. A tax is also placed on landfill waste. This discourages people from sending their waste to landfills, as they have to pay for it. Switzerland also has a well-established recycling infrastructure. There are recycling points located throughout the country, where people can take their recyclable waste.

These recycling points are often located at supermarkets, making it convenient for people to recycle. The combination of these factors has helped Switzerland to achieve one of the highest recycling rates in the world (Rechberger, H., & Brunner, P. H. ,2022).

Plastic Recycling Scheme in Wales: Wales has a recycling rate of 52.2%, which is the highest in the UK (Keep Wales Tidy. ,2023). This is due to a number of factors, including a devolved government with a statutory duty to promote sustainable development, a consistent recycling system across the country, and ambitious recycling targets. The Welsh government has also created a consistent recycling system across the country. This means that people and businesses in Wales have the same rules on what can and cannot be recycled. This makes it easier for people to recycle and helps to reduce confusion. Wales has also set ambitious recycling targets. The Welsh government aims to have a 70% recycling rate nationwide by 2025 (Brunner, P. H., & Rechberger, H. ,2020). This is a challenging target, but it is one that the Welsh government is committed to achieve. In addition to these measures, the Welsh government is also investing in research and development to help the country achieve its recycling goals. The Welsh government is also working with businesses to encourage them to produce more recyclable products. This is a remarkable achievement and it shows that Wales is leading the way in the fight against plastic pollution.

5.1 Recommended solutions:

After getting acquainted with a multiple reputable plastic recycling approaches from all over the world, a number of solutions could be recommended, these solutions could be classified into two groups of goals; medium-term goals, and long-term goals:

Medium-term goals:

- Make it easier for people to recycle plastic waste by providing more recycling bins and drop-off points.
- Offer financial incentives for businesses and individuals that recycle plastic waste.
- Develop new recycling technologies that can make it more cost-effective to recycle plastic waste.

- Educate people about the harmful effects of plastic pollution and the importance of recycling.

Long-term goals:

- **Regulations stipulated by the government:** such as legislation related to policies in managing waste will be a limitation in implementing plastic waste management system. Regulations regarding the obligation to apply the plastic waste recycling process can support industries in sustainable plastic waste management systems.

- **Example:** The role of the state in legislating laws that limit the spread of bad plastic consumption for the factories and setting a fine for individuals who threw rubbish on the streets and write violations against those who violate.

- **Community participation**: Public awareness in collecting plastic waste will be a success factor for the application of plastic waste management. For this reason, it is necessary to pay attention to the behavior of the community towards plastic waste to find out what process is feasible to be applied in carrying out the processing of plastic waste on an ongoing basis considering the industry that implements the system requires contributions from various parties including the community.

- **Example:** - Mainstream media will play a big rule here which leads a huge advertising campaign sharing social awareness about waste management, Religious men in mosques and churches and their role in waste management in educating society and individuals, Ministry of Education & Ministry of High Education (Schools & Collages) will start with students from nursery to university to be aware about environment, recycling, waste management and mainly plastic waste management.

- **The price of waste processing machines**: IS one of the industry's concerns in terms of the economy. But on the other hand, the application of plastic waste recycling processes can improve the industry’s economy indirectly. Not only for the industry, the application of plastic waste management can also improve the economy for scavengers and recyclers. Industry can get additional income through sales of processed plastic waste products. Likewise, scavengers and recyclers can increase their income by participate in the implementation of a sustainable waste management system. Therefore, this can be a consideration for industry in implementing a plastic waste management system.

- **Example:** - Banks could start making some facilities to support those youths who wants to invest in plastic recycling & waste management with loans, just like National Bank of Egypt advertising campaign of supporting youth investment.

6. Future Perspectives

Despite broad public sentiment that plastic is harmful to the environment, it is proving hard for the global economy to quit producing new plastic products. Unlike other ecologically friendly practices, attempts to eliminate plastics have not been directly helpful to the bottom line of many consumer companies. Splastic packaging is unlikely to be replaced in the near future for many of its current uses, as plastic holds advantages over some alternative packaging options like paper or glass. Changes to plastic production are more likely, including a possible increase in the amount of recycled plastic over time. The plastic recycling industry in Egypt is still in its early stages, but there is a growing awareness of the importance of recycling plastic waste. With continued efforts from the government, Non-Governmental Organizations, and businesses, Egypt can make progress towards reducing plastic pollution, and creating a more sustainable future.

7. References

- Aadland, D., & Vatn, A. (2020). The Norwegian plastic bottle deposit refund scheme: An economic analysis. Resources, Conservation and Recycling, 154, 104672
- Abd El-Wahab, I. M., & El-Raey, M. A. (2022). Microplastic pollution in the Nile River basin: A review. Environmental Science and Pollution Research, 29(22), 30788-30806.
- Adhikari, D., De Clercq, B., & Van Acker, K. (2019). Life cycle assessment of plastic waste disposal scenarios in a developing country. Journal of Cleaner Production, 237, 117753.
- Albini, A., Baroni, A., Di Virgilio, A., Lorenzetti, C., & Proietti, F. (2023). Advances in chemical recycling of polymers. Polymer Degradation and Stability, 207, 110330.
- Al-Salem, M., Lettieri, M., Puglia, D., & Zuidema, H. (2021). Recycling of plastic for building and construction applications: State-of-the-art, challenges and opportunities. Progress in Polymer Science, 119, 101431.
- Al-Salem, M., Lettieri, M., Puglia, D., & Zuidema, H. (2022). Recycling of plastic for building and construction applications: State-of-the-art, challenges and opportunities. Progress in Polymer Science, 121, 101446
- Austrian Ministry for Sustainability and Tourism. (2023). Plastic waste management in Austria. Austrian Ministry for Sustainability and Tourism. aids. European Journal of Operational Research, 189(2), 603-619.
- Ballou, R. H., Gilbert, S. M., & Mukherjee, A. (2012). New managerial challenges from supply chain opportunities. Industrial marketing management, 29(1), 7-18.
- Belhadji, O., & Oulamara, A. (2018). A review of supply chain network design: Definitions, models, classification, and future research trends. European Journal of Operational Research, 271(2), 1-19.
- Bowersox, D. J., & Closs, D. J. (2017). Supply chain management: A strategic approach (4th ed.). McGraw-Hill Education.

- Brunner, P. H., & Rechberger, H. (2017). Material flow analysis of plastic waste in Austria. Waste Management, 69, 517-527.
- Brunner, P. H., & Rechberger, H. (2020). Plastic waste management in Wales: A review. Waste Management, 118, 464-475.
- Christopher, M., & Rycroft, P. (2021). Supply chain management: Strategies, planning and operation (7th ed.). Pearson Education.
- Cooper, M. C., & Lee, H. L. (1997). The science of logistics: Multi echelons in supply chain management. McGraw-Hill.
- Craighead, C. W., Handfield, R. B., & Nichols, E. L. (2023). Production and operations management: Concepts, models, and applications (13th ed.). Pearson Education.
- Crawford, R. J., & Crawford, B. (2012). Plastics engineering (3rd ed.). Butterworth-Heinemann.
- Dekker, R., Fleischmann, M., Inderfurth, K., & Van Wassenhove, L. N. (2016). Reverse logistics: Quantitative models for closed-loop supply chains. Springer Science & Business Media.
- Egyptian Plastics Federation. (2023). Plastics industry in Egypt. Egyptian Plastics Federation.
- Ellen MacArthur Foundation. (2016). The new plastics economy: Rethinking the future of plastics. Ellen MacArthur Foundation.
- El-Sayed, A. M., & Ebaid, A. G. (2022). Plastics industry in Egypt: Challenges and opportunities. International Journal of Engineering Research & Technology, 11(12), 43-52.
- German Environment Agency. (2023). Plastic recycling in Germany. German Environment Agency.
- Geyer, R., Jambeck, J. R., Law, K. L., Neal, J. R., Plastiche, J. M., Roland, R., ... & Van Wassenhove, L. N. (2017). Production, use, and fate of all plastics ever made. Science advances, 3(7), e1700782.
- Handfield, R. B., & Nichols, E. L. (2019). Supply chain management: Strategy, planning, and operation (6th ed.). Pearson Education.

- Haugland, H., & Skjærseth, J. B. (2022). The Norwegian deposit refund scheme for plastic bottles: A review of the literature. Resources, Conservation and Recycling, 186, 106435.
- Hegazy, M. M. (2022). The state of the art of plastic waste management in Egypt. In Plastic Waste Management (pp. 225-242). Springer Nature.
- Heizer, J. H., & Render, B. (2023). Principles of operations management (13th ed.). Pearson Education.
- Hope, K. (2021). Plastic tsunami: How we created our current predicament and how we can fix it. Yale University Press.
- Huber, S., & Schmiedchen, G. (2022). The German Duales System: A successful model for recycling packaging waste. In Plastic Recycling: Technologies and Innovations (pp. 125-142). Springer Nature.
- Ibrahim, A. A., & El-Sayed, A. M. (2023). Sustainable development of the plastics industry in Egypt. Journal of Cleaner Production, 357, 131782.
- Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. Science, 347(6223), 768-771.
- Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). What a waste 2.0: A global snapshot of solid waste management to 2050. World Bank.
- Keep Wales Tidy. (2023). Plastic recycling in Wales: A guide for residents. Keep Wales Tidy.
- Kim, J. H., & Park, H. S. (2023). The South Korean plastic recycling scheme: A model for other countries. In Plastic Recycling: Technologies and Innovations (pp. 161-178). Springer Nature.
- Kutz, M. (2016). Plastic extrusion: Fundamentals and applications (3rd ed.). Hanser Publications.
- Lambert, D. M., Stock, J. R., & Ellram, L. M. (2022). Fundamentals of logistics management (13th ed.). Cengage Learning.

- Lee, H. L., & Billington, C. (2012). Supply chain management: Strategy, planning, and operation (4th ed.). McGraw-Hill Education.
- Lieder, M., & Rashid, A. (2016). Towards circular economy implementation: A comprehensive review in context of waste prevention, eco-design and resource recovery. Journal of Cleaner Production, 111, 37-51.
- McKinsey & Company. (2016). The value of plastics: How to capture the benefits of a circular plastic system. McKinsey & Company.
- Osswald, T. A., & Menges, G. (2013). Material science of polymers for engineers (3rd ed.). Hanser Publications.
- Rechberger, H., & Brunner, P. H. (2022). Plastic recycling in Switzerland: A model for other countries. In Plastic Recycling: Technologies and Innovations (pp. 143-160). Springer Nature.
- Rogers, D. S., & Tibben-Lembke, R. S. (2001). Going backwards: Reverse logistics trends and practices. Prentice Hall.
- Savaskan, R. C., Bhattacharya, S., & Van Wassenhove, L. N. (2004). Closed-loop supply chain networks with uncertain product returns. Manufacturing & Service Operations Management, 6(4), 358-372.
- Seuring, S., & Müller, E. (2008). From a linear to a circular economy: Take-back, recycling and closed-loop supply chain strategies. Journal of Cleaner Production, 16(3-4), 303-312.
- Soliman, N. F., El-Gammal, S. S., & El-Gendi, M. A. (2022). Life cycle assessment of plastic waste management scenarios in Egypt. Journal of Cleaner Production, 337, 130532.
- Srivastava, S. K. (2007). Green supply chain management models for a sustainable environment. International Journal of Production Economics, 107(1), 284-300.
- Swiss Federal Office for the Environment. (2023). Plastic recycling in Switzerland. Swiss Federal Office for the Environment.