



Literature Review of Liquid Packaging Board

Degree Thesis

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Abstract:	
<p>The 3'R of Waste management is "Reduce, Reuse and Recycle". Recycling is a concept where waste management is taken and further converted as a material that can be used during different stages of product development. Common recyclable materials are metals, paper, and cardboard, tires, plastics, batteries, and electronics. Liquid Packaging Board are multiple layered containing polymer-coated paperboards, with a layer of aluminum foil and plastic polyethylene. It is naturally believed they cannot be recycled due to their multilayer structure. That is not the case, Paper boards are easily recycled into paper fiber, other material is classified as pulper reject. The report aims to refer analysis of the liquid packaging board (LPB) recycling. The work focuses on studying the recycling process of plastic coming out as pulper reject.</p>	
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1. Introduction

1.1. Background

Recycling is one of the key components of 3'R of waste management after Reduce and Reuse. "Reduce, Reuse and Recycle" are defined as waste hierarchy.

The recycling techniques have been introduced for decades now, but only a few techniques are followed today. Since the time of Plato, Recycling has been evolved throughout history when human beings used to reuse broken tools and pottery when raw materials were scarce. (Recycling Basics, 2021).

The collection and processing of the materials that would be thrown away as trash and reusing them as a product that has significant usage are called Recycling. The following are the steps involved during the recycling process:

- Collection and Processing of the waste materials. After collection of the waste materials, recyclable materials are proceeded to a recovery facility to convert them into a material that can be further used for manufacturing. Recyclable materials are used raw materials.
- The products are manufactured with recycled materials. Some examples of recycled materials are newspaper, steel cans, aluminum, plastic, recovered plastic in carpeting, and park benches.
- Final products made with recycled content.

Recycling has a far-reaching impact on every sector. A well-managed recycling management by a single person or a community has many advantages.



Fig 1. 3'R of waste management (Pluspng.com).

1.2. Aim of Thesis

Main targets to achieve:

- To study recycling of liquid packaging board (LPB).
- To study plastic recycling of pulper reject.

1.3. Compliance with Degree Programme

Recycling as well as technologies and mechanism of recycling is an integrative part of a study program.

2. Literature Review

2.1. Liquid Packaging Board (LPB)

Liquid Packaging Board, as the name stands LPB is used in the packaging of liquid foods and drinks. LPB is used as a container for both liquid and creamy substances packaging such as milk, soup, juice, cream, custard, and sauces for more than 40 years. It protects the food components from the risk of contamination from external influences which could damage the products. The outer layer of the packaging is used to provide ingredients and nutritional information about the product to the consumer. The packaging materials and techniques are required to be excellent for the quality of the food and beverages. Since the inner layer of the package is going to be in direct contact with the food and beverages. LPB has high stiffness, strong wet sizing, and a high barrier coating of plastic (polyethylene). Four layers of plastic (polyethylene) used holds the liquid to prevent any leakage also preventing the migration of airflow. The plastic shouldn't contain any smell or flavor which could affect the product's content. (Infiniumglobalsearch, 2019).



Fig 2. Liquid packaging board (Insights, 2020).

2.1.1. Layers of Liquid Packaging Board

Liquid packaging board is a multi-ply paperboard with the layer of polyethylene, polyethylene, aluminum, polyethylene, paper, polyethylene. Wastepaper from a paper machine is used as a second-last ply before plastic for the packaging which gives more bulk and stiffness. The paper board is used for printing applications. Aluminum foil layer is used for heating and barrier protection purposes. The top layer of plastic is used for the protection of paper packaging. While other layers of plastics used depend upon the application of the product. The layer being in direct contact with the product is plastic.

Mostly there are two types of liquid packaging board. One has a short shelf life while the other has a long shelf life. Packages with short shelf life are barrier coated on both sides with one layer of low-density polyethylene. Packages with long shelf-life use aluminum foil as barrier coating together with polyethylene. Before the products are packaged, they are heat-treated, which helps in energy saving as it does not need to be refrigerated before use.

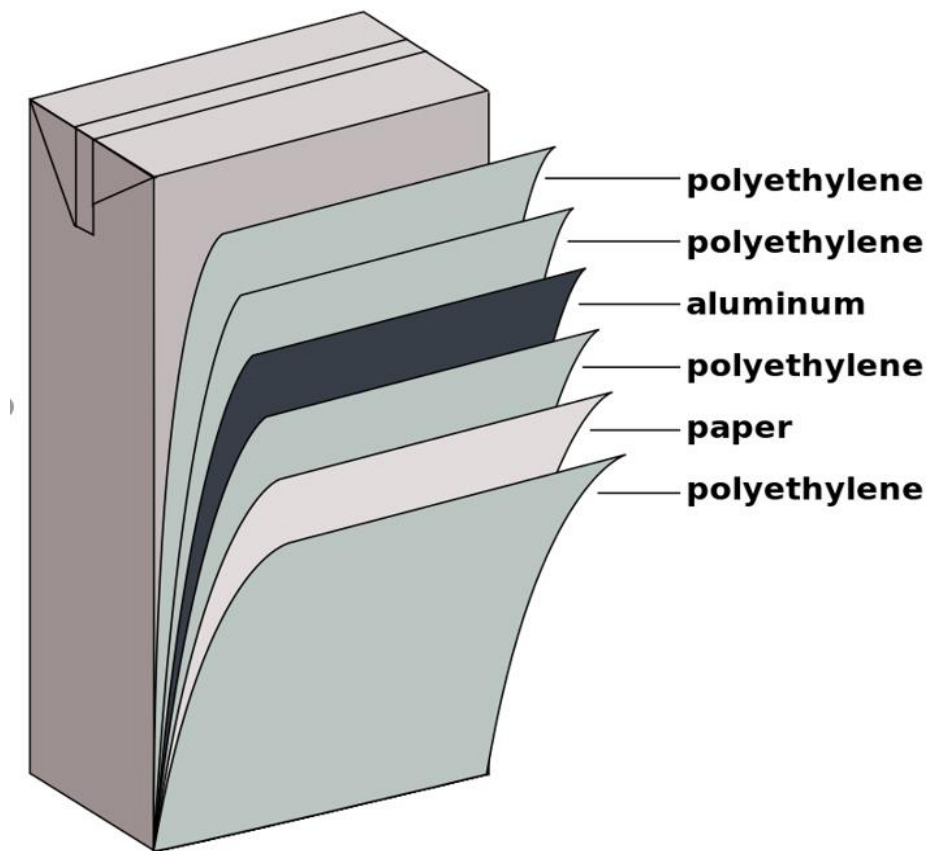


Fig 3. Layers of liquid packaging board (Wikimedia Commons, 2010).

2.1.2. Recycling of LPB

The liquid packaging board has high content of cardboard which can be recycled. Cardboard is a recyclable and biodegradable material made up of renewable resources. Packaging containing 1 liter of liquid consists of 30 grams of cardboard. The cardboard turns into methane if not treated, which causes the increase of global warming with a capacity of 21 times more powerful than carbon dioxide. Recycling of one kg of cardboard can save from the creation of one kg greenhouse gas.

The common method of the recycling of liquid packaging board is by repulping in paper mills. In large container cartons are swirled around with a vat of water. During the process cardboard, plastic and aluminum are separated. The cardboard has properties which absorb the water as a result it is thick slurry. Most of the cardboard fiber is recovered for further process. The plastic and aluminum components are taken out from the mixture. The plastic and aluminum rejected for further process are known as pulper reject. (Snowymonaro, 2021).



Fig 4. Liquid packaging board waste (Tecnofer).



Fig 5. During the recycling process (Wikipedia, 2020).



Fig 6. Final production of cardboard (Tecnofer).

2.2. Environmental Benefits

One of the most advantageous environmental aspects is stopping the garbage from occupying the space of the garbage that cannot be repurposed. The garbage released into the air and water can cause pollution. The need to extract and process from mining and forestry, the raw materials also affect the air and water pollution which can be eliminated by using the recycled materials.

It helps to tackle climate change by reducing the consumption of energy usage, and greenhouse gas emission. Using recycled materials in the manufacturing process, less energy is required than that of the production of new raw materials associated with cost including for transportation, labor used.

The wood and fiber used for the cardboard in LPB are recycled and used as a raw material for a wide range of products like tissues, paper, cardboard. Manufacturing the products from the recycled materials rather than virgin materials reduces the use of trees, water (up to 90%), energy (up to 50%) and chemical waste (up to 90%). (Conserve Energy Future, 2021). Recycling helps in the conservation of natural resources. Recycling paves the way for a greener future.

2.3. Economic Benefits

Waste collection and disposal is reportedly 6 times cheaper than general refuse. Some countries offer money when people contribute to the recycling of a specific product. The repetitive use of recycled resources contributes to the circular economy. Waste management facilities and recycling industries contribute to the employment of personnel. Recycling creates job opportunities towards following sectors like collection, transportation, processing, manufacturing, packaging, and selling of the final recycled products. Recycling helps in a cleaner and greener environment which helps to promote tourism. (Conserve Energy Future, 2021).

Common examples of materials that can be recycled are Metals, Paper, and Cardboard, Plastics, Batteries and Electronics. Plastics such as PET (Polyethylene terephthalate), HDPE (High-density polyethylene), PVC (Plasticized Polyvinyl chloride), PP (Polypropylene), PS (Polystyrene), LDPE (Low-density Polyethylene) are among the recyclable materials. (Sciencing, 2019)

Not all plastics are recyclable stands true. The main aim of plastic recycling is to reduce plastic pollution by not using virgin materials to produce new plastic products.

Liquid packaging board (LPB) is a multiple layered paperboard containing high stiffness, strong wet sizing, and high barrier coating. LPB is mostly used as juice and milk containers. LPB recycling is categorized into four sectors. It can be reprocessed as the original products, shredded packets used as a raw material, recycling chemicals to be used in different products, and incineration with energy recovery. (Evergreenpackaging, 2021).

2.4. Pulper Reject

Reject is word which, is used to describe any substance that can't be recycled or is not biodegradable. Rejected waste is rejected or not further treated in any treatment facility. Most of the cases, it's because it can't be further recycled, or the recycling process hasn't been more developed and sustainable or cost more. (Tecnofer, 2021; Britannica, 2022)

Pulper reject is commonly known as reject, it is amounted to 30% of waste that is remained from Liquid Packaging Board recycling. During the process of paper mill, pulper reject is generated from the recycling processes. 70% of the liquid packaging board produces cardboard while 30% of the reject materials is produced. 30% of the waste is known as pulper reject. It is a solid waste that requires a proper collection facility, and which needs to be transported to the treatment facility. So far, mostly it's dumped into the disposal site. When LPB is recycled, the plastic and aluminium get separated from the fibre waste which is then known as pulper reject. Pulper reject is the mixture of plastic and aluminium waste collected after the LPB treatment. They occur in the form of pulper rags and loose rejects. The name of pulper reject falls into the reject waste which is refused to be further treated because of its properties. (Andritz, 2022; The Hindu, 2022)

Benefits of reject treatment are as follows: (Andritz, 2022)

1. When the pulper reject is transported directly to the treatment facility, reduction of waste disposal and transportation cost to the disposal site by 30%.
2. 25% to over 40% of greenhouse gas emission is reduced resulting into greener and healthier environment.
3. Employment income and final products sale income is generated which comply in income generation.

2.5. Categorization of Pulper Reject Waste

In the mechanical recycling process, collection of the pulper reject is the first step. The collection of the materials is done after the pulper reject materials are separated from the fiber waste. The materials are either picked up from the designated recycling facility or being provided by them for further process.

Sorting plastic waste is the most crucial step. As pulper reject is the mixed waste collection after fiber waste is separated. Among the waste collected, plastic waste is first sorted out. Secondly, amongst the plastic waste, plastics are further sorted out in terms of properties such as color, thickness, density and uses. To lower the risk of impurity of the final products, the process at the recycling plant is carried out by the machines.

The next step is cleaning that comes after since plastic waste is the collection of impurities too. Impurities including the chemical waste collected in the plastic container as well as physical impurities such as adhesives, food residues are cleaned during the washing process.

The plastics are then broken down into smaller pieces when fed into shredders. For the reuse of plastics, plastics are used in other applications such as raw material to produce new products.

After the waste has been classified as a solid waste of plastics, the identification and separation of the waste take place. The classification of plastic waste depends on its density to determine the thickness of the plastic pieces. The process normally takes place when the shredded plastic is placed into a wind tunnel. The thinner pieces float while thicker pieces stay at the bottom of the container. The thinner pieces have low density while the thicker pieces have high density.

The final step of the recycling of plastics takes place when the shredded plastics are transformed into a usable solid product. To form the pellets, the torn plastics will go through the process of being melted and crushed together.

The final product can be constructed from plastic pellets formed. The plastic pellets are then transferred to other recycling facilities to produce the final product. (Recycle Track Systems, 2020).

3. Results

3.1. Environmental Degradation

The process where the natural form of environment is compromised to the extent where the biological diversity is reduced, the concept is known as environmental degradation.

The process affecting the degradation of the environment can be a natural process and external factors can be activities caused by human beings.

Environmental degradation is one of the ten threats officially cautioned by the high-level Panel on Threats, Challenges and Change of the United Nations. “The United Nations International Strategy for Disaster Reduction defines environmental degradation as the reduction of the capacity of the environment to meet social and ecological objectives and needs” (Eionet, 2021).

Environment degradation has become a “most important concern” for humankind over the decades. Environmental Protection and Environmental Resources Management are the efforts taken into consideration to counterpart the problem faced by Environmental degradation. (Wikipedia, 2021).

Plastics have a synthetic property due to which it takes centuries to get decomposed into nature. Plastic does not naturally degrade when released into the environment. The plastic waste that has been landfilled and not recycled in a proper treatment facility starts to hamper the environment in a negative way. The study states that quarter of the plastic waste ends up in ground or freshwater.

The plastic waste disintegrates into smaller pieces further breaking down up to five millimeters called microplastics which further breaks down into nanoparticles measuring less than 0.1 micrometer in size. Nanoparticles are easier to get mixed up in any environment causing degradation.

In the long run plastic waste starts to deteriorate the land and marine ecosystem along with the emission of greenhouse gas. (Internet Archive, 2015).

- Land ecosystem
- Marine ecosystem
- Greenhouse gas emission

3.1.1. Land Eco-system

Commonly plastic waste is dumped into landfills. There's still a lack of waste treatment facilities in many areas which affect the land when it comes in direct contact with the toxic and hazardous chemicals present in the waste. In direct contact with water, they produce hazardous chemicals that affect the soil fertility. The environment is polluted due to the emission of toxic and foul gases from landfills.

Scientists believe that, because of human activities, the earth has been pushed into sixth mass extinction event. Overpopulation has also contributed to the loss of biodiversity and overconsumption of natural resources.

“World Wildlife Fund, according to the report in 2020 found that human activity, specifically overconsumption, population growth and intensive farming has reportedly destroyed 68% of vertebrate wildlife since the year 1970” (Westwingwire, 2021).

“The Global Assessment Report on Biodiversity and Ecosystem Services, in the year 2019 published by the United Nation's IPBES, reports that roughly one million species of plants and animals face extinction from anthropogenic causes, like expanding human land use for industrial agriculture and livestock rearing, along with overfishing” (Discussion, 2021).

The State of the World's Biodiversity for Food and Agriculture Organization of the United Nations in 2019 (Researchgate, 2019) states that “countries report that many species that contribute to vital ecosystem services, including pollinators, the natural enemies of pests, soil organisms and wild food species, are in decline as a consequence of the destruction and degradation of habitats, overexploitation, pollution and other threats” and that “key ecosystems that deliver numerous services essential to food and agriculture, including supply of freshwater, protection against hazards and provision of habitat for species such as fish and pollinators, are declining” (Wikimedia Commons, 2019).



Fig 7. Land eco-system destroyed by plastic waste (Pluspng.com).

3.1.2. Marine Eco-system

Environment degradation, one of the major components affected, is depletion of water resources. Only 2.5% of the water resources on the earth's surface is freshwater available for human consumption and the rest being salt water. Water is vitally important for the course of any living being. Living organism life is dependent on water resources. Water supplies all the necessary nutrients, minerals, and chemicals to all forms of living organisms. Three most uses of the freshwater account for 95% consumption, 85% for irrigation of farmland, golf course and lands, 6% for domestic purposes and 4% for industrial purposes.

Due to the long-lasting durability and its lightweight property, plastic pollution is widely distributed all over the world including water resources such as seas and oceans. The tone of plastic garbage is being dumped near water resources such as small canals and rivers. Seas and oceans are affected when the plastic waste gets mixed following the water flowing from the small water sources.

Each year about 8 million plastic waste is estimated to enter the ocean. EU in particular is responsible for about 0.15 to 0.5 million tons of plastic waste disposal on the ocean. It is estimated by the year 2050, because of increasing plastic business plastic waste will increase in the ocean. From the Arctic to the Antarctic, Ocean is touched by this global scourge. Marine animals like turtles, fish, seabirds, otters, and other species are led to death due to entanglement or poisoning. Plastic bands, net line and synthetic ropes act as a death trap for different species of marine life. Because of the plastic property where it breaks down to form nanoparticles aquatic animals, seabirds consume the plastic as a food that led to death by indigestion. Plastic industries manufacture plastic of various sizes and properties for various purposes. When the plastics are discarded into the water resources, different types of additives that are added to the plastics tend to sorb harmful and toxic contamination. Whoever consumes those plastic particles through accidental ingestion faces hazardous effects. Human health is also affected by the consumption of fish which has chemical contamination. (Ocean Unite, 2021).



Fig 8. Marine eco-system destroyed by plastic waste (the Guardian, 2021).

3.1.3. Greenhouse Gas Emission

Plastic is mostly made up of petroleum or natural gas, plastics are mostly petrochemicals. The production of plastics goes through a heating process for the refining of petroleum. The chemical building blocks for the manufacture of plastics are ethylene and propylene. When these chemicals are combined with other chemicals to produce a polymer, plastic is formed. The formation of plastics is an artificial process where it is responsible for the production of greenhouse gas.

Since the production of its recycling process plastic life cycle emits greenhouse gases into the environment. The severe effects of climate change are greenhouse gas emissions and global warming. Burning of the plastic increases the health risk such as heart disease and respiratory disease as asthma and emphysema. Most common are the skin allergies caused to harmful toxins in the air. The nervous system could also be damaged due to the emission of greenhouse gases.

A study was conducted on the ground every day to measure the quantity of small plastic particles that fall out of the wind. The study shows that per day 249 plastic pieces were found per square meter. The study concluded that microplastics can be transported over the distance of 95 kilometers. (The Conscious Challenge, 2019).



Fig 9. Greenhouse gas emission (World Meteorological Organization, 2021).

4. Challenges

Plastics are cheaper, lightweight, and durable products which can be used in the packaging of any product. Plastic packaging is popularly used worldwide as a packaging material. Plastic packaging is used over other packaging materials such as glass, metal, aluminum, and paper. Due to the increasing use of plastics over the past few decades, that has created hazardous effects for the loss of economy and environment. Recycling is one of the most used methods to tackle and solve the problem of plastic waste. Globally, different technologies and recycling advancements have been introduced to encourage recycling measures.

Many challenges are faced along the way of recycling process. For one is the increasing availability of plastic recycled waste. There is yet to be managed a stable supply of recycled plastic waste materials. Technology and the process have yet to be developed in an efficient way. The recycled plastic waste can be used as a raw material as a building block to produce any other materials. However, the process of taking the garbage into the treatment facility and further sorting of the plastic waste still must be managed in a consistent manner.

4.1. Lack of Awareness

In modern society, consumers are more careful about recycling and sustainability. Still there is a lack of awareness among people about the harmful effect that can be caused by using plastics. People still use plastic as a single life use and discard them away mixed with other waste materials. There is not a proper way of sorting the waste material starting from home, in larger organizations such as shopping malls, industries and factories. The proper discard of plastic waste is much more important while landfilling of the waste material in the environment. People should be aware of the proper discarding method and the recycling process. In several countries around the world, the government is taking initiative in the recycling process by setting up different colored-coded recycling waste sorting methods. People are getting information by the government about the proper waste disposal method and its advantage in the recycling process. The government is also taking into consideration the use of plastic. Plastics are replaced by paper bag packaging and other packaging material. Shops and food

vendors use paper as a packaging material over plastic which could reduce the use of fresh plastic.

4.2. Less Demand for Recycled Products

Plastic recycling is not a new initiative which is certainly not going away anytime soon. Now with the plastic recycling rate hovering with new technologies introduced, there is still not much demand for recycled products. The discussion remains the same, if virgin and recycled plastic material deliver the same standard in quality why should one pay more. Study shows that recycled products have slightly higher prices than those of virgin products. To produce recycled plastic there are many factors affecting the cost such as the transportation of the waste, treatment and final production of the product cost including the labor cost in all the steps. As a result, recycled products tend to cost more than those of virgin products. Whereas the quality of the recycled product is always in discussion if it can outperform the virgin product. If not, why should one pay more for the same product? Manufactures and consumers argue whether recycled plastics can reach the benchmark of high-quality standards expected from the product. (Spylobal.com, 2021)

Manufacturers do not want to include recycled plastic as a building block to produce new product considering the factor that its quality has already been compromised because of the contamination during the process from initial product to its waste disposal and the treatment.



Fig 10. Recycled products (Jess Thompson, 2015).

4.3. Additive Used in Pulper Reject

Liquid Packaging Board are laminated together with the use of additives because of its multiple layered property with different types of materials. Plastics, aluminum foil, paperboard are all used in the liquid packaging board, so additives like fillers, colorants, lubricants, and foaming agents are found. Additives like food remain, juices, milk often remained in the packaging acting as an external factor during the recycling process. Most of the time, because of improper waste disposal system along with liquid packaging board other materials are also mixed as a general waste.

5. Future Possibilities

5.1. Circular Economy

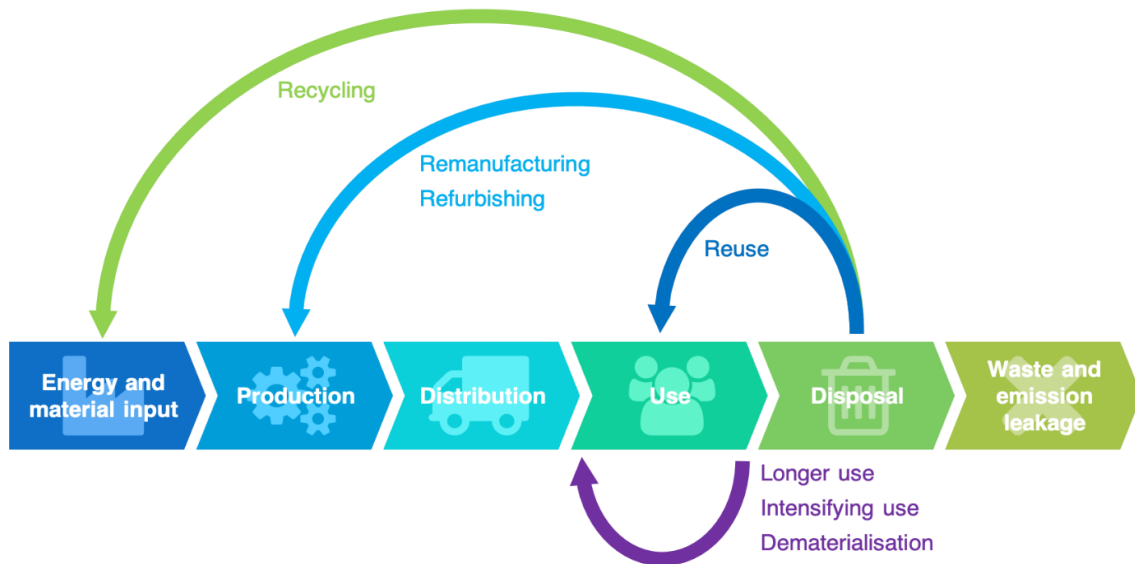


Fig 11. Circular economy (Wikipedia, 2020).

As we enter the third decade of the millennium, the concept of circular economy has gained popularity. Manufacturers and recycling initiatives have worked together in creating small steps to set the future of recycling as a surge in circular products. When 100% closed-loop recycling systems is achieved recycled materials are used to build a product that of equal value to the virgin product. Circular economy helps to reuse the products and raw materials, which results in clearing the pollution and restoring the natural systems.

Circular economy is the concept of manufacture and expenditure, which involves sharing, leasing, reusing, repairing, refurbished and recycling of existing materials, if possible, without degrading the material. (Recycle Track System, 2020).

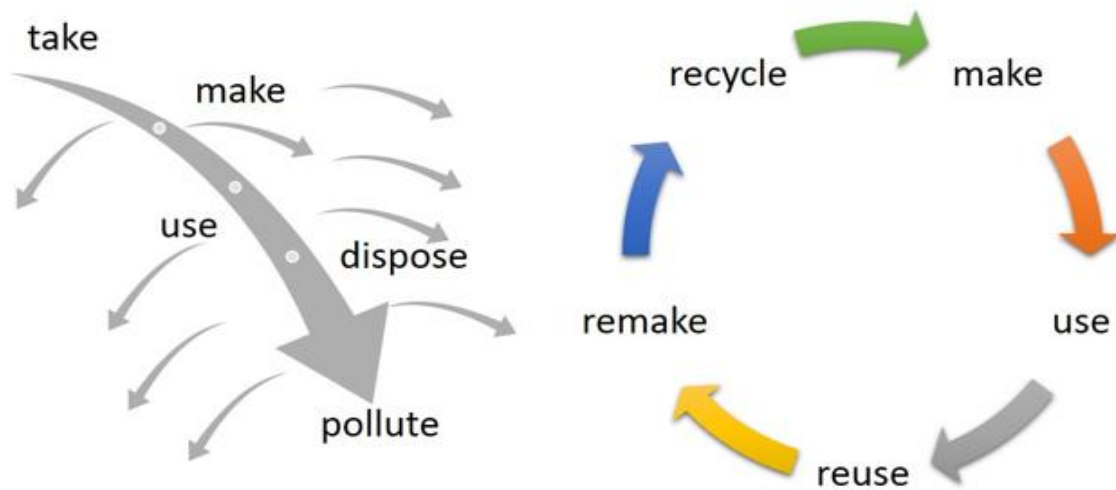


Fig 12. Circular economy structure (Circular economy, 2016).

Linear economy is the concept where the products are manufactured using the natural resources which are discarded as a waste material because of the way it is designed. The process is summarized as “take, make and waste”. (Recycle Track System, 2020).

5.2. Use of Recycled Polyethylene

Polyethylene is the type of plastic used in liquid packaging board. Polyethylene is categorized as Low-Density Polyethylene and High-Density Polyethylene.

Low-Density Polyethylene (LDPE) is a thermoplastic made from petroleum. Its molecular structure is marked by a central chain of carbon atoms and several secondary chains that branch outwards. As the name says, it has low-density structure. It is most used to lend the material a flexible character enabling it to retain a high degree of tensile strength.

High-Density Polyethylene (HDPE) is a petroleum made thermoplastic. HDPE molecular structure is devoid of polymer branching. As the name says, polymer chains are compact together which causes it to have high-density structure. It results in properties as high tensile strength, powerful impact resistance, low absorption of humidity and chemical resistance.

Both the materials, LDPE and HDPE are 100% recyclable. The most common products manufactured with the recycled plastics are: (Polychem USA, 2017).

- Flooring
- Paneling
- Plastic lumber
- Rope
- Toys
- Gardening tools
- Furniture equipment
- Dustbins and cartons

5.3. Environmental benefits

The initiative of using reusable fabric bag has resulted the number of plastic bags in the last 20 years to be reduced around 70%.

- Conservation of natural resources: Recycling of plastic and reusing it to make other materials helps in the conservation of the use of natural resources such as energy, water, resources, and petroleum. Recycling plastic also helps in the decrease of the level of carbon dioxide.
- Saves landfill space: When the proper waste management system is introduced, less landfill space is used as a result the waste materials are used for recycling.
- Reduces emission of Carbon dioxide (CO₂): The main cause of climate change is the huge consumption of materials goods. With the recycling process less, pollution is emitted as a result it helps in reduction of carbon dioxide gas.
- Protects ecosystem and wildlife: Plastics dumped in the land resources and marine ecosystem effects the ecosystem and wildlife. Recycling plastic waste helps in maintenance and lifecycle of ecosystem and living creatures.
- Prevents pollution: Recycling lessen the need of transportation and mining which are the main cause of pollution. Recycling helps with air and water pollution. (AzoCleantech.com, 2012).

5.4. Shifting to Bio-based Products

Plastic made from plants or other biological material is known as bioplastic. Instead of the petroleum used in normal plastic, bioplastic biological material is used as a building block. Polylactic acids (PLAs) are made up of extracted sugar from plants like maize and sugarcane. Polyhydroxyalkanoates (PHAs) can be manufactured from microorganisms. The bio based plastics have several usages as PLA is used in food packaging, utensils, plastic bottles and textiles, and PHA is mainly used for medical purposes like stitches for the wound and cardiovascular stitch patches. The cheapest source of bioplastic is PLA. (Nationalgeographic.com, 2018).

Plastics made from petroleum or plants like corn are among the cheapest materials for things like packaging. Many small-scale businesses have developed more alternatives like growing fungus into lightweight furniture. In the U.S the Department of Agriculture is using milk fill to create packaging that keeps food fresh.

Government in many countries, have applied ban of the use of single-use plastic cutlery and straws calling it “War of Plastic”. It helps to reduce litter and cut the amount of plastic waste. It is stated that on average a person uses 18 single time use plastic plates and 37 single-use cutleries every year. (theGuardian, 2021).



Fig 13. Bioplastic material for bakery products wrapping. (Upload Wikimedia).



Fig 14. Bottles made from cellulose acetate bio grade (Bioplastic Wikipedia, 2011).

6. Conclusion

Plastics are without doubt the most lightweight, durable, strong, versatile, and cost-efficient product. Plastics have been mostly used as a packaging material. While studying the liquid packaging board, which is made up of multiple layered polyethylene plastic, aluminum foil and paper where additives are used to glue the materials together and printing ink is used for product and nutrients information. Liquid packaging board is recycled when discarded. 70% of the content is paper which is easily recycled for the manufacture of cardboard. 30% of the waste containing aluminum foil and plastic along with additives are discarded. This waste is commonly known as Pulper reject. It is a term used to describe the remaining waste material separated from the paper waste. During the recycling process, liquid packaging boards are repulped in the paper mills. LPB are swirled around in a large containing with vast amount of water. Paper absorbs the water making it a thick slurry component while the aluminum foil and plastic is rejected.

Pulper reject is a refused waste after the LPB treatment. After the successful extraction of fiber waste from the process, the waste containing the mixture of plastic, aluminum along with additives cannot be recycled or is not biodegradable so they are known as pulper reject. There has not been proper sustainable development towards the pulper reject recycling techniques and its future possibilities. Given the condition that the world is currently facing plastic waste pollution and many organizations and companies around the world have focused on processing the pulper reject recycling process smoothly and which could also generate income in various sectors. Many technologies are developed, and a small-scale development process is taking place towards the recycling process of plastics collected in the pulper reject. It is a great innovation that has taken the interest of the public from around the world. It is emerging technology and there is a further area for improvements around the sustainable recycling process of plastics.

Plastics can further be sorted out with proper management sorting techniques and devices which can be recycled. Recycling plastic waste is not a new initiative, but it is still yet to be developed in a managed way. The government is taking initiative in developing the process of recycling in many countries by researching more information and techniques required. People are becoming more aware of the recycling process and manufacture of a new product using recycled material as a raw material.

Benefits of recycling plastic waste have enormous advantages to the economy and conservation of the environment. Due to recycling plastic waste which ends up in landfills, are reduced contributing towards the conservation of environment. It helps to reduce the degradation of the environment. Land eco-system is saved because of the recycling process which helps to stop the production of greenhouse gas. Marine wildlife which is affected because of the plastic waste ending in ocean and seas, is saved from indigestion of chemical substances and entanglement in plastic sources.

Governments and people are taking initiative measures for the reduction of plastic usage by using canvas bags for grocery shopping and banning plastic packaging with other materials like paper. Ban of plastic cutlery and straws are taking place in many small-scale and large-scale businesses.

List of References

1. US EPA. 2021. Recycling Basics | US EPA. [online] Available at: <<https://www.epa.gov/recycle/recycling-basics>> [Accessed 17 November 2021]. 2021.
2. 2021. [online] Available at: <Sciencing. 2021. List of Materials That Are Recyclable. [online] Available at: <<https://sciencing.com/list-materials-recyclable-8073576.html>> [Accessed 17 November 2021].> [Accessed 1 December 2021].
3. 2021. [online] Available at: <Evergreenpackaging.com. 2021. Paperboard Packaging | Evergreen. [online] Available at: <<https://evergreenpackaging.com/paperboard/>> [Accessed 17 November 2021].> [Accessed 1 December 2021].
4. Conserve Energy Future. 2021. *What is Recycling and Why is Recycling Important? - Conserve Energy Future*. [online] Available at: <<https://www.conserve-energy-future.com/why-is-recycling-important.php>> [Accessed 1 December 2021].
5. Infiniumglobalresearch.com. 2021. *Liquid Paperboard Market Size, Share, Trends, Analysis, Industry Report 2025 / IGR*. [online] Available at: <<https://www.infiniumglobalresearch.com/agriculture/global-liquid-paperboard-market>> [Accessed 1 December 2021].
6. Snowymonaro.nsw.gov.au. 2021. [online] Available at: <<https://www.snowymonaro.nsw.gov.au/DocumentCenter/Home/View/4872>> [Accessed 1 December 2021].
7. Tecnofer. 2021. *Pulper Rejects Treatment | Tecnofer*. [online] Available at: <<https://www.tecnofer.biz/en/installations/pulper-reject/>> [Accessed 1 December 2021].
8. Recycle Track Systems. 2021. *The Complete Plastics Recycling Process - Recycle Track Systems*. [online] Available at: <<https://www.rts.com/blog/the-complete-plastics-recycling-process-rts/>> [Accessed 1 December 2021].
9. <https://www.eionet.europa.eu/>. n.d. *environmental degradation*. [online] Available at: <<https://www.eionet.europa.eu/gemet/en/concept/15154#:~:text=Environmental%20degradation%20is%20a%20process,or%20caused%20by%20human%20activities>> [Accessed 1 December 2021].
10. Internet Archive. 2021. *USPTO Patents Application 10789442 : United States Patent and Trademark Office : Free Download, Borrow, and Streaming : Internet Archive*. [online] Available at: <<https://archive.org/details/gov.uspto.patents.application.10789442>> [Accessed 1 December 2021].

11. En.wikipedia.org. 2021. *Environmental degradation - Wikipedia*. [online] Available at: <https://en.wikipedia.org/wiki/Environmental_degradation> [Accessed 1 December 2021].
12. Hinkes, M., 2019. *The State of the World's Biodiversity for Food and Agriculture*. [online] ResearchGate. Available at: <https://www.researchgate.net/publication/331408550_The_State_of_the_World's_Biodiversity_for_Food_and_Agriculture> [Accessed 1 December 2021].
13. Commons.wikimedia.org. 2021. *File:The State of the World's Biodiversity for Food and Agriculture – In Brief (FAO).pdf - Wikimedia Commons*. [online] Available at: <[https://commons.wikimedia.org/wiki/File:The_State_of_the_World%27s_Biodiversity_for_Food_and_Agriculture_%E2%88%92_In_Brief_\(FAO\).pdf](https://commons.wikimedia.org/wiki/File:The_State_of_the_World%27s_Biodiversity_for_Food_and_Agriculture_%E2%88%92_In_Brief_(FAO).pdf)> [Accessed 1 December 2021].
14. Discussion, U., 2021. *The Climate Hoaxers are targeting beef.* [online] US Message Board 🗨️ Political Discussion Forum. Available at: <<https://www.usmessageboard.com/threads/the-climate-hoaxers-are-targeting-beef.894645/page-3>> [Accessed 1 December 2021].
15. Westwingwire. n.d. *humans-exploiting-and-destroying-nature-on-unprecedented-scale-report*. [online] Available at: <<http://www.westwingwire.com/humans-exploiting-and-destroying-nature-on-unprecedented-scale-report/>> [Accessed 1 December 2021].
16. Ocean Unite. 2021. *MARINE PLASTIC POLLUTION - Ocean Unite*. [online] Available at: <<https://www.oceanunite.org/issues/marine-plastic>> [Accessed 1 December 2021].
17. The Conscious Challenge. 2021. *Plastic & Land — The Conscious Challenge*. [online] Available at: <<https://www.theconsciouschallenge.org/ecologicalfootprintbibleoverview/plastic-land>> [Accessed 1 December 2021].
18. Spglobal.com. 2021. *Recycled plastics market will feel the heat from consumer demand in 2020*. [online] Available at: <<https://www.spglobal.com/en/research-insights/articles/recycled-plastics-market-will-feel-the-heat-from-consumer-demand-in-2020>> [Accessed 1 December 2021].
19. Recycle Track Systems. 2021. *The Future of Recycling — Looking to 2020 and Beyond*. [online] Available at: <<https://www.rts.com/blog/the-future-of-recycling-looking-to-2020-and-beyond/#:~:text=The%20future%20of%20the%20recycling%20industry%20lies%20very,of%20raw%20materials%20produced%20by%20the%20recycling%20process.>> [Accessed 1 December 2021].

20. Polychem USA. 2021. *Polyethylene Recycling*. [online] Available at: <<https://polychem-usa.com/polyethylene-recycling/>> [Accessed 1 December 2021].
21. AZoCleantech.com. 2021. *Recycling of High-Density Polyethylene (HDPE or PEHD)*. [online] Available at: <<https://www.azocleantech.com/article.aspx?ArticleID=255>> [Accessed 1 December 2021].
22. Environment. 2021. *Bioplastics—are they truly better for the environment?*. [online] Available at: <<https://www.nationalgeographic.com/environment/article/are-bioplastics-made-from-plants-better-for-environment-ocean-plastic#:~:text=Bioplastic%20simply%20refers%20to%20plastic%20made%20from%20plant,be%20made%20from%20polyhydroxyalkanoates%20%28PHAs%29%20engineered%20from%20microorganisms.>> [Accessed 1 December 2021].
23. the Guardian. 2021. *Single-use plastic plates and cutlery to be banned in England*. [online] Available at: <<https://www.theguardian.com/environment/2021/aug/27/single-use-plastic-plates-and-cutlery-to-be-banned-in-england>> [Accessed 1 December 2021].
24. Encyclopedia Britannica. 2022. *refuse | Definition & Examples*. [online] Available at: <<https://www.britannica.com/topic/refuse>> [Accessed 13 February 2022].
25. AG, A., 2022. *Reject treatment systems*. [online] Andritz.com. Available at: <<https://www.andritz.com/products-en/group/recycling/reject-treatment-system>> [Accessed 13 February 2022].
26. Editor, R., Page, O., 2022, B., Quotes, S., Sports, O., gardens, H. and basics, G., 2022. *Garbage segregation: the basics*. [online] Thehindu.com. Available at: <[https://www.thehindu.com/news/cities/mumbai/types-of-garbage/article19748289.ece#:~:text=Reject%3A%20Broadly%2C%20anything%20that%20isn,\)%2C%20and%20e%2Dwaste.](https://www.thehindu.com/news/cities/mumbai/types-of-garbage/article19748289.ece#:~:text=Reject%3A%20Broadly%2C%20anything%20that%20isn,)%2C%20and%20e%2Dwaste.)> [Accessed 13 February 2022].
27. Andritz.com. n.d. *Purple Rags*. [online] Available at: <<https://www.andritz.com/resource/blob/43678/808af0e49753072dfefb8eda81b9ff25/pp-pulprecycled-rejectsystems-pulperrags-data.pdf>> [Accessed 13 February 2022].
28. Ouali, M., 2018. *Thermo-catalytic reforming of pulper rejects from a secondary fibre mill*. [online] ScienceDirect. Available at: <<https://www.sciencedirect.com/science/article/abs/pii/S1755008418301170>> [Accessed 13 February 2022].
29. WEIMA Maschinenbau. 2022. *Shredding pulper ropes | reject shredders - WEIMA Maschinenbau*. [online] Available at: <<https://weima.com/en/shredding-pulper->

ropes/#:~:text=This%20waste%20is%20usually%20referred,pulper%20rejects%20con-
tain%20valuable%20materials.> [Accessed 13 February 2022].

30. Bellmer GmbH. 2022. *Reject Handling*. [online] Available at:
<<https://www.bellmer.com/separation-technology/paper-industry/reject-handling/>> [Ac-
cessed 13 February 2022].
31. Semantic Scholar. 2020. *Mechanical recycling of packaging waste*. [online] Available at:
<<https://www.semanticscholar.org/paper/Mechanical-recycling-of-packaging-waste-Feil-Pretz/7fcd458e1cda07ea918a5ab229776f595fcf4e7f>> [Accessed 13 February 2022].
32. Havstad, 2020. *Biodegradable plastics*. [online] Semantic Scholar. Available at:
<<https://www.semanticscholar.org/paper/Biodegradable-plastics-Havstad/55f857aa485bbaeae8c1cc22c235048b47adc81e>> [Accessed 13 February 2022].
33. Peake, L., 2020. *Chapter 23 - Plastic waste in the United Kingdom*. [online]
ScienceDirect. Available at:
<<https://www.sciencedirect.com/science/article/pii/B9780128178805000232>> [Accessed
13 February 2022].
34. Dumbili, E., 2020. *The challenge of plastic pollution in Nigeria*. [online] ScienceDirect.
Available at:
<<https://www.sciencedirect.com/science/article/pii/B9780128178805000220>> [Accessed
13 February 2022].
35. Khalid, M., 2022. *Recent trends in recycling and reusing techniques of different plastic
polymers and their composite materials*. [online] ScienceDirect. Available at:
<<https://www.sciencedirect.com/science/article/abs/pii/S2214993721001378>> [Accessed
13 February 2022].

Figures

1. Commons.wikimedia.org. 2021. *File:TBA packaging components.gif - Wikimedia Commons*. [online] Available at: <https://commons.wikimedia.org/wiki/File:TBA_packaging_components.gif> [Accessed 1 December 2021].
2. Tecnofer. 2021. *Pulper Rejects Treatment | Tecnofer*. [online] Available at: <<https://www.tecnofer.biz/en/installations/pulper-reject/>> [Accessed 1 December 2021].
3. En.wikipedia.org. 2021. *Circular economy - Wikipedia*. [online] Available at: <https://en.wikipedia.org/wiki/Circular_economy#/media/File:The_Circular_Economy_concept.png> [Accessed 1 December 2021].
4. En.wikipedia.org. 2021. *Circular economy - Wikipedia*. [online] Available at: <https://en.wikipedia.org/wiki/Circular_economy#/media/File:Linear_versus_circular.jpg> [Accessed 1 December 2021].
5. Upload.wikimedia.org. 2021. [online] Available at: <https://upload.wikimedia.org/wikipedia/commons/8/89/Sweets_packaging_made_of_PLA-Blend_Bio-Flex.jpg> [Accessed 1 December 2021].
6. En.wikipedia.org. 2021. *Bioplastic - Wikipedia*. [online] Available at: <https://en.wikipedia.org/wiki/Bioplastic#/media/File:Bottle_made_from_Cellulose_Acetate_Bi-ograde.JPG> [Accessed 1 December 2021].
7. 2021. [online] Available at: <<https://pluspng.com/reduce-reuse-recycle-earth-png-4334.html>> [Accessed 5 December 2021].
8. Insights, S., 2021. *Paper-Plastic Liquid Packaging Carton Market Insights and Forecast by 2027; Key Players are Tetra Laval, SIG Combibloc, ELOPAK, Greatview, Evergreen Packaging, Nippon Paper, Likang Packing*. [online] openPR.com. Available at: <<https://www.openpr.com/news/2162466/paper-plastic-liquid-packaging-carton-market-insights>> [Accessed 5 December 2021].
9. the Guardian. 2021. *More than 14m tonnes of plastic believed to be at the bottom of the ocean*. [online] Available at: <<https://www.theguardian.com/environment/2020/oct/06/more-than-14m-tonnes-of-plastic-believed-to-be-at-the-bottom-of-the-ocean>> [Accessed 5 December 2021].

10. World Meteorological Organization. 2021. *Greenhouse gases*. [online] Available at: <<https://public.wmo.int/en/our-mandate/focus-areas/environment/greenhouse%20gases>> [Accessed 5 December 2021].
11. Thompson, J., 2021. *A Closer Look at Recycling | Perspectives On The Environment*. [online] Sites.psu.edu. Available at: <<https://sites.psu.edu/perspectivesontheenvironment/2015/02/08/a-closer-look-at-recycling/>> [Accessed 5 December 2021].