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A Global Look at the Market Potential of Liquid Container Board and Its Ability to Reduce Plastic Waste – A Brief Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

The use of aseptic packaging creates many opportunities around the world to replace plastic based packaging of liquid and food-based containers in the near future. This will lead to a cleaner environment, less pollution within the air and the sea, and will help stimulate growth within the economy. Soon the use of aseptic packaging containers will be global which will help decrease the amount of pollution along with the number of landfills throughout the world. Many of the world regions highlighted in this paper are decreasing their plastic usage while increasing their recycled product production. As societal values are shifting more towards green materials and sustainable

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living, the general consumer is becoming more educated and aware of their ability to impact companies and government views, and are placing a larger value on sustainable, recyclable packaging. Aseptic packaging will be an important part of consumerism and the growing market contributes to a more sustainable, greener world as the efficiency of the recycling and production processes using aseptic packaging materials will improve over the coming years, allowing more fiber, plastic and aluminum to be recovered and used in the creation of new APC products.

Keywords: Aseptic packaging materials; beverage carton; liquid container board; milk carton; paper board; old corrugated container; paper properties; recycling; repulping.

1. INTRODUCTION

The production of paper, board as well as paper and board-based packaging materials requires manufacturers to have a more favorable environmental footprint in regards to the use of raw materials [1,2]. Legislature action and customers put pressure on manufacturers in the food, beverage, and pharmaceutical industry sector to have a more favorable environmental footprint to reduce plastic consumption and the associated microplastic pollution [3,2]. One feasible way is to package solid and liquid products made from fruits, milk, and meat into paper-based packaging containers to replace plastic based packaging materials [2]. In the United States of America some juice, wine, and milk products are already packaged in containers that are paper based. These packaging containers are referred to as liquid packaging board, aseptic packaging container (APC), or Polymer coated paperboard (PCPB), is a paper product used in the food industry to package and store liquids that prevents microorganisms from entering the product [4]. Through the use of aseptic processing the paper is sterilized, and the container is sealed to prevent microorganisms from infecting the product [5]. During the sterilization process every component of the packaging process is sterilized including equipment, fillers, product and packaging material. This process allows the sustainable liquid container to possess the ability to extend the shelf life of liquid food products, especially when refrigerated. Dairy and fruit juice are some of the most notable products that are often packaged in liquid container boards, but many producers of liquid food products are beginning to use APC [6].

To be accepted as eco-friendly packaging material, recycling processes and solutions for collecting these materials, such as the in Europe widely implemented Tetra Pack process in Europe, need to be implemented to recover the materials contained in the recycled APC packaging material [2].

Fig. 1, represents an illustration by Dölle & Jeeva of APC packaging material [2]. APC can be seen as a composite material that includes generally 75% Paper, 20% Low-Density Polyethylene (LDPE), and 5% Aluminum [7,2]. Based on product requirements, an Aluminum layer may be used. The paper board layer, the most valuable material for recovery might be manufactured by of virgin or recycled pulp and is embedded between multiple layers of LDPE. The aluminum and LDPE layers cannot be used at present time as food packaging raw material and is in most cases is downcycled and or used as byproduct for composite material [2].

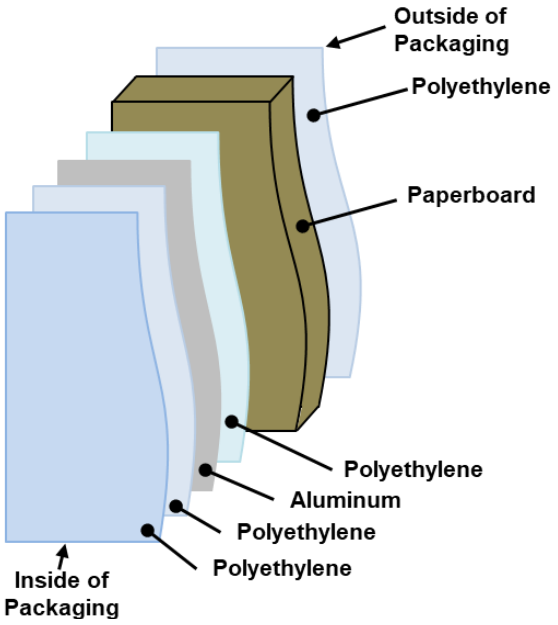

Fig. 1. Illustration of an aseptic packaging container material [2]

According to a market report by Global Industry Analysts, the Global Liquid Packaging Market reached an estimated US$326.8 Billion in 2020. This was during the beginning of the COVID-19 pandemic. The market is projected to grow to US$463.6 Billion by 2027 [8]. Currently, the United States and Chinese markets are projected to grow the fastest, but some European

countries, such as Germany, are also proving to have promising markets. Germany for example, is forecast to grow at approximately 4.8% CAGR (Compound annual growth rate) [8]. Aseptic packaging shows promise in an increasing market potential and presents the opportunity to replace plastic based packaging and reduce plastic waste globally, consumers have been growing more open to purchasing sustainable packaging, leading to an increase in demand for aseptic packaging, in particular [9].

The following review gives n brief overview of aseptic packaging practice and its potential in Europe, Asia, North and South America, Africa and the bordering Mediterranean area, Arabia, and Australia.

1.1 Europe

As previously mentioned, APC extends the shelf life of liquid products substantially, the sterilized product packed in an aseptic beverage carton is shelf stable for over 6 months [10]. In addition, APC allows many products that typically would need refrigeration to be stored on shelves. This greatly reduces energy consumption and costs, as it removes the need for large scale refrigeration. The aseptic packaging industry is paving the way towards more sustainable packaging. Besides its ability to improve shelf life of liquids, APC also has less of an environmental impact than similar food storage options. The world market for APC increases by 6 to 8% a year [11]. As expected, the amount of liquid food being packaged in APC is growing too. In 2009, in the European Union, APC was used to package approximately 70 million liters of liquid food a day [11]. Typically, all these packages turn into unusable waste [12], but, unlike many kinds of plastic, APC can be recycled relatively easily. Plastic bottles and bags, which in many cases are unable to be recycled, make up 5 million metric tons of plastic waste annually in the UK alone [13]. In Australia, the Australian Bureau of Statistics reported a staggering 76 million metric tons of plastic generated in 2018-19, an increase of 10% from the prior 2 years [14]. While some of this plastic can be recycled, such as rigid plastics like food containers, and some flexible plastic wraps [15], much of it is disposed of in landfills or burned for energy. In contrast, according to the European Food packaging Bulletin, Tetra Pak, who is a prominent producer of APC, 651,000 metric tons of used beverage cartons were recycled globally in 2014. As the ACP market has grown, this number is suspected to grow as well [16]. APC has proved to be a very efficient way to maximize the usefulness of resources and materials, keeping them in the economy for as long as possible while minimizing waste. The volume of waste produced, and the greenhouse gas emissions from this waste, has put pressure on all major countries to improve their environmental footprint and in turn, move towards reusable and recyclable material like aseptic packaging. A direct quote from the European Commission in 2018 states, “by 2030, all plastics packaging placed on the EU market is either reusable or can be recycled in a cost-effective manner” [17] This statement is a very promising sign for those interested in producing APC and shows a need for improved recycling methods and procedures for the preexisting packages. Today, liquid packaging represents the largest market for extrusion-coated materials, not just in Europe but across the globe, with an emphasis on two-sided extrusion coatings for milk cartons and aseptic packaging for UHT milk and juices. Extrusion-coated/laminated materials also account for an estimated 20%-30% of all flexible packaging structures in Europe today, most of them complex laminates employing films and aluminum foils [18]. European usage of aseptic construction is more widespread than in North America, undoubtedly related to the energy and space-saving benefits. Overall, European liquid packaging market share for aseptic packaging is 75%, with North American liquid packaging use currently in inverse ratio. Gable-top cartons take approximately 63% of total consumption and 19% share of domestic production. Aseptic packaging is said to be more energy efficient in processing and far more energy-efficient in storage, eliminating the refrigeration requirement until opened and reducing volume requirements and weight during transportation [18]. Demand is forecast to continue to rise by an average 2%/annum, but there are differences between the end-use market segments. Flexible packaging shows the highest growth opportunity at 2.5%/ annum as the liquid packaging market matures to grow at just 1%/annum [18].

1.2 Asia

Packaging food is a concern that every company must meticulously plan and design what the material used will be. Most companies' solution for this problem has been aseptic packaging. Aseptic packaging is the sterilization of the packaging container to prevent unwanted organisms or bacteria into the product [19]. This

is largely because of the polyethylene-based materials layered in and outside the containers. The increase in aseptic packaging has been due to its properties to increase the shelf life of the products. For example, in Asia soy milk has a much higher consumption rate and the problem they were having was they needed to extend the shelf life for high distribution [20]. Due to this problem, companies switched to an aseptic packaging because the materials used to make the packaging allows products to remain bacteria free for longer periods of time while not having any reduction of nutrients [19]. This factor is very important especially for products that need to be made at a high temperature like the sterilization and pasteurization of milk. The use of Aseptic Packaging also has positive effects on the environment. Most of the Aseptic packaging can be recycled, while the plastic-based packaging it would be taking over cannot. In 2019, a research team in Asia was able to conduct experiments to calculate how much plastic debris was being polluted within the rivers of Europe and Asia. The study found that the top 10-20 polluting rivers are all mostly located within the Pacific-Asia region and account for 67%-95% of the global total of plastic pollutants. Out of all the pollutants found, around 90% of the microplastics found were hard plastics, usually used for food containers, plastic sheet, and film while only 0.1 percent was other foam related plastics [21]. Along this line, another study was done in 2022 to see how much plastic was polluting Asian oceans due to the importation of packaging plastics from other countries. This report found that 6.5 kilotons/year of plastic food packaging was leaked into the marine environment due to the Netherlands. 75 % of this waste is polluted through countries in Asia due to the exportation of it for disposal [22]. The pollution of these plastics is not good for any environment, especially marine life. The use of aseptic packaging could lead to a slow of the pollution in Asia and could eventually bring it to a halt. Due to the large increase in popularity of aseptic packaging, many countries in Asia have switched to using it full time. However, this has caused a large increase in the amount of waste. For example, “approximately 46,000 metric tons/day of packaging waste was generated in China in 2010, of which, 2,500 metric tons was composite packaging waste” [23]. This is largely due to the large increase in manufacturing but not having the innovative technology to recycle all the material used. This is because the material used for aseptic packaging like the polyethylene and aluminum in the containers make it harder to be recycled without being manually separated. In addition, very little material is recycled so most of the material ends up in a landfill. Because of this, whatever material is salvaged by China must be hand sorted, using methods which are yet to be determined as illegal or polluting, and is traded between China, Malaysia, Korea, and Japan [24]. With all this domestic trading of recycled material, it must be heavily regulated. This is to ensure the limiting of the pollution during the trade, and nothing is illegally disposed of. In addition, China was also banned from importing any of the materials because of the amount that is disposed of and to prevent more from being added to their landfills. The material cycle is mainly regulated by Japan and Malaysia to ensure the materials are recycled properly and not violating any of the domestic and local laws [25]. Along with the positive affect that the use of aseptic packaging has on the environment, it would also have a positive effect of the economy of Asia. The use of Aseptic packaging within the economy in the east would stimulate lots of growth for new ways within food packaging and the exploration into better ways to recycle the goods. A study was performed in Indonesia in 2021 that investigated how the use of aseptic packaging will affect the economy of not only Indonesia but also the countries that are based around it as well. The study found that not only will Indonesia’s economic framework improve but it will also help to establish a sort of economy for the underdeveloped countries that border Indonesia [26]. While the discontinued use of the plastic-based containers would decrease bringing down the demand for the plastic-based supplies, the new use of the aseptic packaging container would increase more in turn increasing the supply for the materials needed to produce these types of packaging while also increasing the supply for the materials needed to recycle materials like APC as well.

1.3 North and South America

In North and South America, liquid containerboard is used as an alternative packaging for processed food and liquid beverages. The demand for liquid container boards in North and South America has increased due to the increasing production and consumption of dairy and juice products. Typically, liquid containers have been made of plastic but recently consumers have been open to purchasing more sustainable and environmentally friendly packaging. Many large

companies like McDonald's, Nestle, and Coca-Cola have joined a Sustainable Packaging Coalition (SPC) to cater to increased consumer demand for sustainable packaging [27]. Each company in the Sustainable Packaging Coalition aims to reduce waste, reduce energy consumption, and reuse packaging materials to lower their environmental impact. With consumers becoming more environmentally conscious, replacing plastic containers with environmentally friendly containers is being considered by companies within the packaging industry. Liquid containerboard, in particular, has been considered for use in liquid beverage carton packaging. In North America, packaging is a large and important industry that continues to grow. In Canada the market for containers and packaging increased by 3.1% in 2021, raising the total market value to $22.3 billion [28]. The Covid-19 pandemic that started in 2020 is pushing customers toward online shopping for retail and grocery products. The most recent trend of online shopping has created a demand for packaging from the paper industry. In the United States, the market for containers and packaging has increased by 1.7 % in 2021 [XX?]. In both Canada and the United States, the market for containerboard and packaging has increased in 2021 and is forecasted to keep increasing in the future. Furthermore, paper packaging made up 59.6% of the packaging and container market's total volume [XX?]. In order to get products to customers, producers must use packaging made of appropriate material. Paper is often used as a sustainable alternative to plastic packaging and containers. However, using paper for packaging and containers makes a substantial amount of paper waste. In 2022 the paper industry in the United States produced 67 million tons of waste from paper products and recycled 68 percent of that waste [29].

Most of the waste produced by the paper industry in the United States is used to make liquid containerboard since it has the lowest cost of all the potential products from recycled fibers. Traditionally, liquid beverages are packaged in high-density polyethylene (HDPE), Polyethylene terephthalate (PET), glass, or containerboard. The consumption of liquid containerboard in this region could replace the use of these plastics, decreasing plastic waste. According to the American Chemistry Council, in 2018 the sale of HDPE resin for bottles in the U.S. amounted to 3,315 million pounds [30] HDPE made up 25% of total packaging plastic volume in the U.S. in 2019 [31].

By replacing HDPE bottles with liquid containerboard bottles the amount of HDPE usage in the U.S. would decrease, leading to less plastic waste. While this would also increase the amount of paper waste in the U.S., the high fraction of recycled containerboard would ensure that the total amount of solid waste going to landfills would decrease. Replacing these plastics would drastically decrease packaging plastic waste production in the U.S. In South America, liquid containerboard finds use in the packaging of many different products. In 2012, Tetra Pak, an aseptic packaging company, made up 57% of the wine packaging market in Chile [32].

In 2019, according to the South Carolina Forestry Commission, paper cartons, boxes, cases, and other packaging made up 19% of Mexico's paper and paperboard market, making it one of the top four commodities in the sector [32]. In the past few years, liquid containerboard has increased yearly within each packaging sector in South America. With this much demand for liquid containerboard packaging in the region, producing liquid containerboard to replace HDPE packaging may be a profitable industry. In Argentina, the total milk production increased to 11.575 million metric tons in 2020 and was predicted to increase by 225,000 tons the following year [33]. This amount of unpackaged product poses the opportunity for liquid containerboard to flourish in the region. A study on the Municipal Solid Waste (MSW) in Bahía Blanca, Argentina discovered that packaging and containers made up a large component of the plastic MSW of the city [34]. These containers can be replaced by paper containerboard, lowering the amount of plastic MSW. In 2017, the average person in Tandil, Buenos Aires, Argentina produced 2 grams of HDPE waste per day [35]. To cut down on the increasing plastic waste alternative containers are needed. These studies suggest that not only is the demand for liquid containers in the region increasing but also that there is a need to replace plastics to reduce solid waste. In 2008, Tetra Pak conducted a case study that analyzed the distribution chain for the aseptic carton-packaging sector in South America from their customers to retailers [36]. The study focused on the distribution of dairy and juice products in Brazil, Venezuela, and Argentina because those are their main products for the region and their largest market area in South America. The study found that in Argentina the dairy market accounts for 11% of the total production in the food sector. It also found

demand for liquid container boards in Brazil, where fruit juice and carbonated drinks are the most preferred drinks for lunch and dinner. Preference for juice and dairy products suggests a high demand for liquid containers that can be supplied by liquid containerboard. Also, in Argentina it was found that dairy products are an important asset to the Argentinean market, but they prefer their milk chilled over ambient packaged products [36]. This statistic means that aseptic packaging is an important factor in the Argentinean market, so there is a high demand for aseptic packaging in Argentina. In Venezuela, there is a demand for aseptic packaging, but the lack of political stability and price control for everyday grocery products led to a declined consumption [36]. The rising production of milk and plastic container waste in North and South America suggests a growing market and demand for liquid containers in the region. This demand can be met by the production of liquid containerboard in order to reduce plastic waste. Already, a large fraction of plastic waste in the region is made of plastic packaging and containers that can be replaced by containerboard. These factors suggest a large market potential for liquid containerboard in the region as well as a possibility to decrease a large source of plastic waste.

1.4 Africa and the Mediterranean

Two locations of interest are Africa and the Mediterranean. These locations both already APC and have the capability to recycle and reuse material from carton board to make more. Although these regions have the manufacturing capacity and growing industries, markets in Africa and parts of the Mediterranean are not large and therefore make up a small percentage of the market value. There are also many factors to explore to determine recycling feasibility. These are all things to consider when evaluating a shift from plastic to paper based aseptic packaging. In Africa, there are two main manufacturers of liquid containerboard. These companies are Nampak and Mpact. Other paper companies in Africa include Sappi, Onward and Mondi. These companies, however, do not produce aseptic containerboard. Nampak's paper products “comprise cartons, boxes and boards, and it serves several markets including personal care, tobacco, food and beverages” [37]. Nampak is based in Johannesburg and is Africa’s largest manufacturer of paper products. Mpact is based in Gauteng and is the leading recycler of recovered paper and plastics. “Mpact Ltd offers corrugated packaging, recycled-based carton board and containerboard, as well as recovered paper collection services” [37]. The existence of these two companies shows that Africa could adopt aseptic packaging and already has the capability to reuse and recycle it. “In 2026, the South African containers and packaging market is forecast to have a volume of 4 million Tons, an increase of 18% since 2021” [37]. This shows the market in Africa is expected to grow, making this location an economically viable location for the manufacturing of paper based aseptic packaging. Although the industry is growing, it accounts for only a small fraction of the global market. South Africa accounts for less than 1% of the global containers and packaging market value. This is because the locations where recycling in Africa is viable account for a small percentage of the whole. According to Lavee and Khatib [38], the items that affect recycling rate are “population size and density, geographic location, current waste levels, and current waste management system.” Despite Africa’s high population, Africa has some of the lowest waste generation, and a geographic location with few raw materials to make paper [39]. Due to the limitations of the African geographical region, there exists an upper limitation of production. This stems from a lack of raw material such as wood and inland water [40]. There is also a large distance between consumers and recycling mills which makes it infeasible to recycle in many locations and difficult to procure raw materials in others. Due to differences in social and economic conditions between Mediterranean nations the market potential of aseptic packaging containers is varied. EU countries such as Italy, Greece, and Spain have relatively high packaging waste recycling rates while Croatia, Cyprus, and Malta do not. Increased rates of recycling could increase the market potential of APC since more access to recycled fibers could drive down the cost of production according to 2019 data from the European Environmental Agency [41]. Another factor that increases the market potential for aseptic packaging container in EU member Mediterranean nations are regulations such as, Directive 2019/904, which bans single use plastics including food containers made from expanded polystyrene, beverage containers made of expanded polystyrene, and products made from oxo-degradable plastic [42]. Regulations such as this make it easier for APC to compete with plastic containers since macroeconomic factors are limiting the use of plastic while also increasing the cost of using

plastics through taxation. From the European Commission (2021), “A uniform call rate of €0.80 per kilogram will be applied to the weight of plastic packaging waste that is not recycled.” Therefore, companies are incentivized to switch to more expensive recyclable plastics or find alternatives such as APC [17]. Despite the APC industry in the EU benefiting from regulation it is worth considering that the APC industry in Europe is already very developed. “In the year 2015, Europe occupied the largest market share of liquid carton packaging, while this demonstrates that APC has been widely adopted in Europe it could also mean the potential for growth is lower and could slow down. Other areas of the Mediterranean could also have market potential, for instance, parts of the Middle East, Turkey, and North Africa. The issue is people in some of these areas consume less, produce less waste, and do not have as many legal incentives to utilize APC over plastic containers. Furthermore, because there is no established APC industry in these locations that creates another barrier since most APC would need to be imported from other regions. According to Meghwal & Murlidhar [43] “The main limitations of [APC] are: the initial capital cost, highly skilled operators, and complexity of the plant, which arises from the necessity to sterilize packaging materials, pipelines, storage and working tanks, filling area, surfaces in filling machine, and maintenance of sterile air.” So, producing APC in developing nations may be a costly endeavor with the risk that there are not enough consumers for APC. Overall, in the Africa and Mediterranean the APC market is growing; however, outside of the EU the market potential is weak. Should Africa and parts of the Mediterranean start consuming more containerboard products, then there would be a larger number of recycled resources and more potential consumers. If those nations also take legislative action against plastic containers that would also encourage APC consumption.

1.5 Arabia

Saudi Arabia is also pushing for a replacement in plastic containers and finding a way to increase their usage of APC goods. Since 2021 Saudi Arabia has been the largest pharmaceutical industry. Though, they now are set to pursue a shift towards locally produced and packaged drugs. If Saudi Arabia is willing to convert from their plastic packaging to the usage of APC packaging, this could have a huge impact on the market of liquid container boards and open many opportunities for vendors. Just to put in perspective, Saudi Arabia has invested roughly SAR 275 million which is around 73.33 million in USD currency. The investment went towards a company named Almarai which is a Saudi Arabian food & drink company which produces many of the juices, bakery, dairy and nutrition for babies across the middle east and Africa. This means that Saudi Arabia expects that at some point in the near future that APC is going to grow even bigger than it is now. Overall, hopes are that Saudi Arabia will be able to decrease their usage of plastic and increase their APC usage. According to SASO many rules have been put into place regarding plastics goods. These rules include a plastic ban on certain plastic materials. Such as bags, plastic liners, food packaging bags, and ect. To have a country completely ban the use of these popular materials will have a big impact on many vendors who distribute their goods to Saudi Arabia. Expectation is the Saudi government will see a big increase in their usage of APC products since there will be a demand increase [44].

1.6 Australia

In Australia, many drastic steps are being taken in an effort to reduce their carbon footprint and environmental impact. Key 2018 to 2019 results of Australia’s green movement include that the proportion of recyclable packaging increased from 88% to 89%, plastics recycling rate increased from 16% to 18%, and average recycled content increased from 35% to 38%. In Australia, the post-consumer packaging recovery rate in 2018-19 is estimated at 50%. Of that percentage, paper & paperboard had the highest recovery rate at 63% (National Retail Association, 2022) [45]. This demonstrates that more than half of Australia's paperboard is recovered and at a very high rate. The Australian government “plans to make 100% of the country's packaging to be reusable or compostable by 2025” [46]. This would lead to an increase in paper packaging unless there were companies that figured out how to create biodegradable plastic (bioplastic) that was less expensive than paper packaging but with similar strength properties. If this development occurred, it could influence the containerboard industry in the future. Aseptic packaging becomes especially useful within the milk processing industry of Australia, as the milk undergoes an Ultra-High Temperature Processing (UHT). This milk is then packaged in APC to ensure freshness. In 1997-98, UHT milk sales rose by

18% on the previous year, with the share of UHT milk sales rising from 5.4% to 6.4% of the total milk market. Much of the strength of UHT growth on the local market is due to supermarket sales. In general, supermarkets account for about 50% of all milk sales and this proportion is rising. In the general market, UHT sales comprise about 6% of milk sales, but in supermarkets UHT sales comprise more than 11% of sales [47,48].

2. FUTURE OF ASEPTIC PACKAGING CONTAINERS

Over the world many countries have enacted legislature to promote paper-based packaging to replace plastic bags for example [3]. This resulted that food, beverage and pharmaceutical industries shifting toward using more renewable packaging. As prognosed by Precedence Research the estimated worldwide market volume for liquid packaging containers in 2021 is $ 460.58 billion with an expected growth to $ 716.70 billion by 2030 [48]. Allied Market Research estimates that the aseptic packaging market was worth $15,408.8 million in 2020 and is predicted to grow to $32,301.4 million by 2028, with a Growth of 9.8% between 2021 and 2028 worldwide and 5.7% in North America [49].

However, the impact of COVID-19 and the Ukraine war on the above predictions has yet to be evaluated for the present and future.

The business outlook for APC packaging is promising, but to meet environmental regulation and being accepted as eco-friendly packaging solution recycling processes for the used APC need to be implemented in many parts of the world.

3. RECYCLING OF ASEPTIC PACKAGING CONTAINERS

Packaging material consist of many different materials such a glass, aluminum and polyethylene terephthalate (PET) for soda bottles and milk containers. However, some drawbacks exist that prevents a more widely use. Glass containers are is heavy, eventually causes high fuel consumption for transportation, and is fragile, PET does not provide a sufficient oxygen barrier for many items, and metal is opaque. Ideal packaging designs for most packaging requirements can be designed by mixing different materials [48-50].

Every chosen packaging solution requires different recycling approaches. For instance, recycled glass containers are separated in in different color fractions. Aluminum cans are collected in many counties in the world as valuable material. Both materials are upcycled to produce new packaging containers [51].

To recycle or recover fiber material contained in the APC material, as shown in Fig. 2, it is essential that already implemented processes in the paper manufacturing industry need to be considered as shown by Dölle & Jeeva [2].

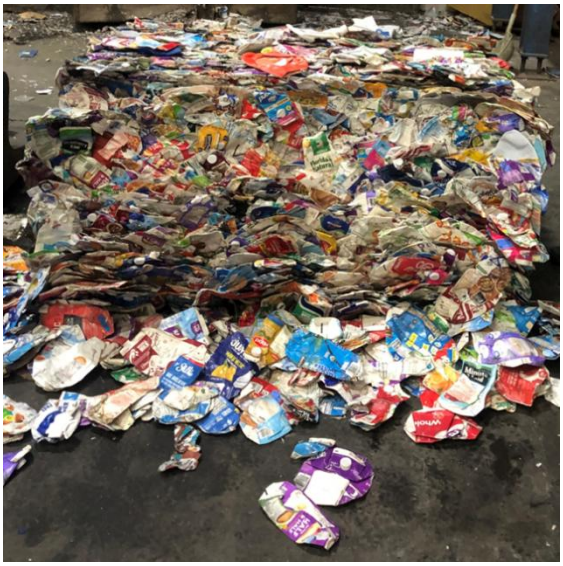

Fig. 2. Recycled packaging containers [52]

Repulping processes, as shown in Fig. 3., as a simple process sketch, are used today in a paper mills Stock Preparation (SP) system to prepare the fiber material received for the actual paper making process. This processes for repulping are already designed to remove any larger contaminants recycled material can contain such as but not limited to plastics, metals, sand, glass, and closed-cell extruded polystyrene foam (XPS) also known as Styrophoam.

Today's commercial repulping processes use centrifugal, gravity and friction forces to disintegrate the fiber material and can be designed to process of over 3000 metric tons of dry material per day [53] at various Solid Content (SC). The Low Consistency (LC) repulping process has a SC of up to 5% to 8% and works on a continuous basis. High Consistency (HC) repulping systems work around 18% SC in 30-40 minutes batch cycles [8] utilizing a helix type rotor design compared to the star flat rotor

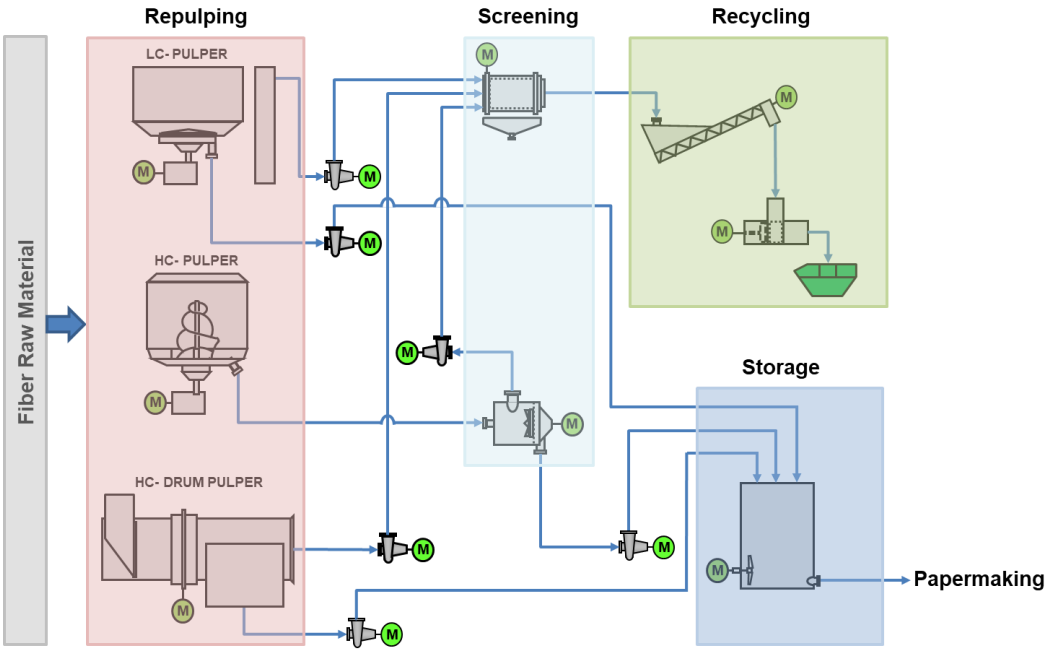

Fig. 3. Low Consistency (LC), High Consistency (HC), and drum pulping system [2]

design of LC repulping processes. Drum Pulping (DP) as a continuous repulping system can repulp the recovered fiber material up to 28% [54,55].

LC, HC, and DP systems have internal and or external screen devices employed based on the type of recovered material processed [2]. The repulped fiber material is diluted to approximately 4% to better remove the above-mentioned unwanted material. Recovers valuable material such as metals and plastic are upcycled to produce new metal and plastic materials [56]. The fiber slurry is processed further and utilized for the papermaking operation.

For APC containers for example Tetra Pack, design is APC products with sustainability in mind to make recycling easy [57] and has developed a specific recycling process utilizing the above-described repulping processes to recover the individual components of the APC material. The fiber material extracted from the recycled APC materials is then reused to manufacture new paper-based materials such as corrugated containers [58]. The recovered Aluminum and Polyethylene residues are repurposed as additional components for the manufacturing of tiles [59].

Any recycling process tailored to the manufacture of paper products needs to be able to produce large scale quantities of several 100 tons per day to supply the needed fiber material for large scale paper production.

4. CONCLUSION

The use of aseptic packaging creates many opportunities that companies around the world may start looking into. The use of this new type of packaging will lead to cleaner environments, less pollution within the air and the sea, and will help stimulate growth within the economy of the east. The positive effects of this new style of packaging have proven that they will out way the negative effects like the more complicated process of recycling. Increased production of this packaging in Asia will soon start for the better and will help to improve the way that consumer goods are packaged from here on out. Along with the use of these newer designs for more renewable packaging in Asia, many countries around the world are looking to make the jump as well. Soon the use of aseptic packaging containers will be global which will help decrease the amount of pollution along with the number of landfills throughout the world. Many of the regions highlighted in this paper are decreasing their plastic usage while increasing their recycled product production. Aseptic Packaging will become a fundamental part of liquid and food-based containers. The efficiency of the recycling and production processes of APC will improve over the years as technology improves allow more fiber, plastic and aluminum to be recovered

and used in the creation of new APC products. As societal values are shifting more towards green materials and sustainable living, the general consumer is becoming more educated and aware of their ability to impact companies and government views, and are placing a larger value on sustainable, recyclable packaging. Aseptic packaging is an important part of consumerism, and the growing market contributes to a more sustainable, greener world.

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DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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