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FOOD PACKAGING AND GIG ECONOMY: BIODEGRADABLE MATERIALS, CURRENT MARKET, CHALLENGES, AND FUTURE PERSPECTIVE

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Abstract:

Changing lifestyle and the advancement of technology have led to the emergence of online food delivery as a promising sector in the gig economy. There is a parallel increase in the demand for alternative sustainable food packaging materials to traditionally used synthetic plastic, thanks to the negative impact of synthetic plastic on health and the environment. The Indian government is also boosting the market for biodegradable packaging materials through the Swach Bharat Abhiyan. Several Indian companies are well-established in this market; simultaneously, several entrepreneurs are emerging with their novel ideas for making cost-effective and competent biodegradable materials. Although the share of biodegradable materials in the food packaging market is very low in today's scenario, a massive amount of employment generation in this field in the future is possible, owing to increased awareness regarding the adverse impact on health and the environment caused by widely used synthetic plastic.

Keywords: *Gig Economy, Biodegradable Packaging, Biopolymers, Revenue, Health Impact.*

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Introduction:

The Gig economy can be considered as the economy that is concentrated around temporary and flexible services, which most often involve online platforms as a medium of connection between customers or clients and the service provider. [Janadari, (2020), pp. 1-14] [Vallas, (2020)]. Thousands of workers are joining the gig economy with the advancement of on-demand digital platforms [NITI Aayog, (2022)]. It mainly assists the workers by allowing them to work independently and flexibly [Oranburg. (2018)]. Examples include online taxi rides, online food delivery, event management services, or even personal services like parlor facilities at home, home renovations, repairs, etc. Various services such as catering, sound, and decoration provided during multiple events like weddings, annual gatherings, live concerts, etc, can also be considered part of this booming sector.

Online food delivery has gained ample attention because of its immense growth potential [Sun, (2024), pp.1216-1234]. According to a report published by "Market Research Future," the Online Food Delivery Market of India was valued at USD 72.12 billion in 2024 and is projected to grow from USD 84.53 billion in 2025 to USD 352.72 billion by 2034 [Dhapte, (2025), pp. 128]. It has been anticipated that online shopping and take-away food delivery services have become a major part of the Indian lifestyle, especially in urban areas. With the ease of online platforms such as Zomato, Uber Eats, Swiggy, Blink It, and Zepto, as with the groundbreaking revolution in online money transfer such as UPI, mobile wallet, and Paytm, more and more people are relying on

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outside food. [Kulkarni, (2021)]. Also, the hectic life and the increasing percentage of working women further boost this tendency. With this ever-increasing demand for online food delivery, undoubtedly, there is a parallel increase in the demand for food packaging materials. As mentioned in the report of "Fortune Business Insights," the food packaging market was estimated at around $394 billion worldwide in 2018 and will extend up to US$ 606 billion by 2026 [Fortune Business Insight, (March 2025)].

India is also contributing significantly to the food packaging market. According to a Horizon Grand View Research report, the Indian food packaging market generated a revenue of USD 21,237.9 million in 2024 and is predicted to produce a revenue of USD 34,735.7 million by 2030. The Indian food packaging market is also expected to grow by a CAGR of 8.5% from 2025 to 2030 [Horizon Grand View Research, (2025)].

Synthetic materials in food packaging:

Plastic, being an adaptable material, has transfigured the food packaging industry over the past few decades.[Marsh,(2007) ,] Due to its cost-effectiveness and numerous desirable properties, it has become the omnipresent substance in the food packaging industry. Petroleum-based polymers (plastics) such as polyethylene [Marsh, (2007)] viz: low-density polyethylene and high-density polyethylene (LDPE, HDPE respectively) [Ghatge, (2020), pp.1-14], polyethylene terephthalate (PET) [Marsh, (2007)], polypropylene(PP) [maddah, (2016), pp.1-12], polyvinyl chloride(PVC) [Gharbawy, (2022), pp. 143-153], polystyrene (PS) [Marsh, (2007)] and Polycarbonates. (PC) [Singh Sisodia, (2022), pp. 553-556] are some of the commonly faced plastics in various food packaging materials. LDPE is the most commonly used inexpensive material for plastic films. It has wide implementation in manufacturing, such as food wraps, squeezable food bottles, frozen food packaging, bread bags, and flexible lids [Shah, (2008), pp. 248]. PP is economical, has higher heat resistance, and transparent plastic is used in various food packaging, including microwave-safe trays, yogurt cups, takeaway boxes, snack wrappers, plastic bottles, and lids [Shah, (2008), pp. 248] PET is used in bottles, trays, and special packaging that extends food shelf life[Shah, (2008), pp. 248]. Similarly, PVC is used in bottles, cling wraps, and meat blister packs [Shah, (2008) ,pp.248]

Health and Environmental effects of plastic waste:

Since plastic is pervasive in food packaging, there is a high risk that very minute plastic particles enter the human body when such packaged food is ingested. These minute plastic particles are collectively termed microplastics. There are two categories of microplastics: primary microplastics are tiny plastic particles purposely manufactured, and secondary microplastics are formed when plastic breaks down naturally. It is observed experimentally that microplastics affect numerous parts of the human body. Regarding the effects on the respiratory system, microplastics lead to oxidative stress in the airways and lungs when inhaled. Gastrointestinal symptoms, like abdominal pain, bloating, and changes in bowel habits, are also observed to be associated with microplastics[Lee, (2023), pp.301]. Continuous exposure to microplastics can also lead to some serious diseases, including contact dermatitis[Heilig, (2011), pp.587-590], colorectal cancer [Oddone, (2014), pp. 12431-12444], and pancreatic cancer [Ruder, (2017), pp.651-657].

Microplastics are tough to remove from the environment and remain for a longer duration. A considerable amount of plastic waste is deposited in water bodies. Wastewater treatment systems do not accurately metabolize plastic particles, leading to harmful effects on aquatic and human life[Devi, (2022), pp. 205-209],[Zolotova, (2022)],[Hodkovicova, (2022)], [Inwati, (2024)]. According to the recent reports published in Nature, India has become one of the largest plastic waste producers, producing 9.3 million tonnes (mt) of plastic

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waste annually. It has surpassed major polluters like Nigeria (3.5 mt), Indonesia (3.4 mt), and China (2.8 mt). India is now contributing 20 % of the world's plastic waste. [Joshua W., (2024), pp. 101-108]

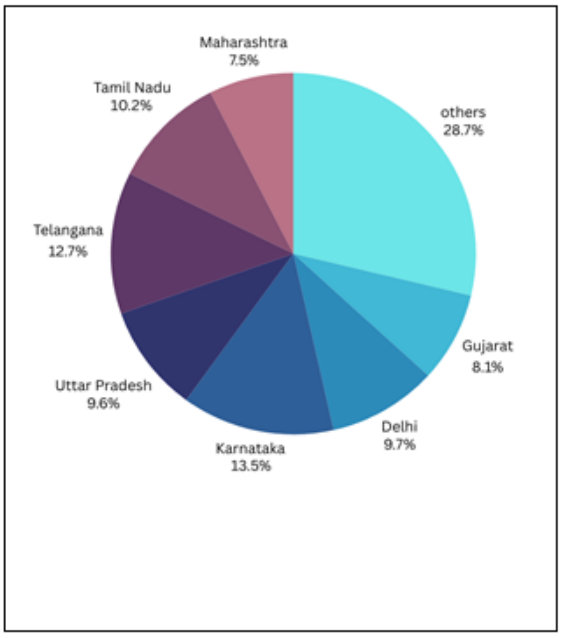

Fig. 1 State /Union Territory-wise plastic waste generation in 2021-2022 (Total waste 3901780 tonnes)[#]

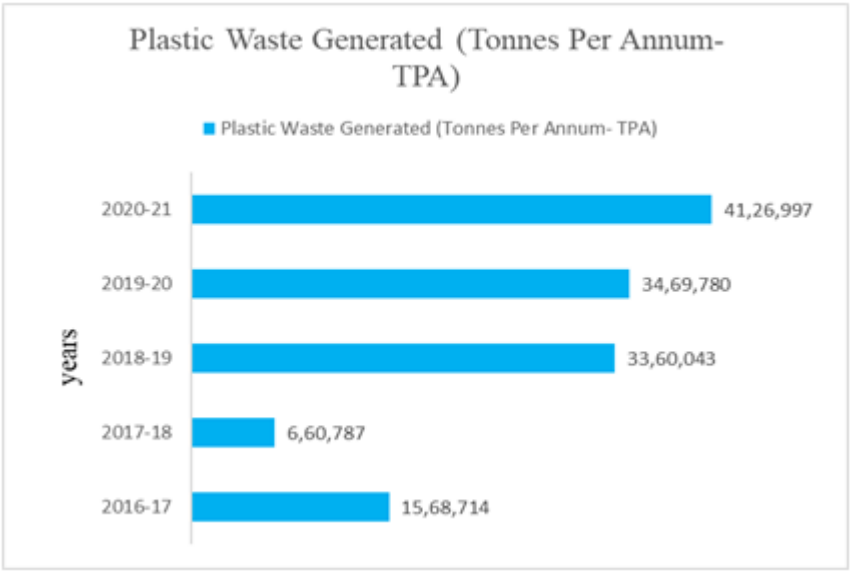

Fig. 2. Plastic waste generated in India annually from 2016 to 2021[#].

[#](Data obtained from Central Pollution Control Board - Ministry of Environment, Forest and Climate Change - Government of India)

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Introduction to biodegradable packaging materials:

Considering all the above factors, there is a drastic urge for sustainable and cost-effective food packaging that easily gets absorbed in the environment upon being discarded. This can liberate thousands of dollars spent on waste management, and lower the potential hazards to the environment and consumer health. Such packaging materials are collectively referred to as biodegradable packaging. Unlike traditional plastics, these materials decompose through biological processes into innocuous compounds like carbon dioxide, water, and biomass. Hence, minimise the environmental and health threats significantly. Biodegradable packaging is either made of biodegradable materials or biodegradable polymers, which are further classified as natural and synthetic polymers. Biodegradable materials include Paper and Cardboard, Bagasse, Cornstarch, bamboo, Seaweed, etc. These materials are treated chemically to improve their properties and to make them sustainable for food packaging. Biodegradable natural polymers enclose plant-based polymers such as cellulose, starch, etc, and animal-based polymers such as chitin, Chitosan, Alginate, Collagen, Sericin, etc. Synthetic polymers are Polylactic acid (PLA), Polycaprolactone (PCA), Polyhydroxyalkanoate (PHAs), Poly(butylene succinate) (PBS), Nylon 2-nylon 6, Poly(glycerol sebacate), poly(y-Glutamic acid), etc.

1. **Natural Biopolymers**

   Starch is cheap and derived from natural sources, so it is widely used in food packaging. It is mainly used as a raw material for making plates, cups, sandwich wraps, and trays [Altaf, (2022)][Leya,(2024)]. **Cellulose** is a plant-based polymer used as a raw material for strong, flexible food packaging films that reduce oil absorption, prevent moisture loss, for pizza and ice cream cones [Maraz, (2019), pp. 66-84] [Leya, (2024)]. **Lignin** can be combined with other polymers like starch and PLA to make biodegradable and strong packaging films [Anushikha, (2023)]. **Chitin** is a natural carbohydrate in crustacean shells, insects, and certain fungi. It is the second most common biopolymer after cellulose. It is used in food packaging as a coating or film to extend shelf life by preventing microbial contamination and limiting oxygen exposure[Leya,(2024))][Maraz, (2019), pp.66-84][Agarwal, (2022), pp. 117-144]. **Alginates** from seaweed and bacteria are safe biopolymers used in biodegradable, edible food packaging due to their thickening and stabilizing properties [Leya,(2024)][Maraz, (2019), pp. 66-84].

   Carrageenan is a natural polysaccharide from red seaweed, mainly used as a thickener and stabilizer in food. It is used as a coating for meat, fish, and poultry to extend shelf life [Leya, (2024)],[Maraz, (2019), pp. 66-84]. **Agar** is another natural polysaccharide from red seaweed. It has strong mechanical properties, [Leya, (2024)],[Maraz, (2019), pp. 66-84]. **Collagen**, found in animal tissues. Collagen films are used in meat processing as they help keep meat juicy, reduce shrinkage, and absorb moisture [Leya, (2024)]. **Gelatin**, made from collagen, forms flexible, clear films that protect food but need strengthening for better durability. Modified gelatin films improve water resistance and help keep food fresh longer [Leya, (2024)].

2. **Synthetic Polymers**

   a. **Polylactic Acid (PLA)** is a biodegradable plastic made from natural sources like corn, sugarcane, and potatoes. It is strong, safe for food contact, and easy to process, making it popular for food packaging. Cups, containers, overwraps, and blister packs are often made using PLA. Most of the time, it is blended with plasticizers like glycerol to improve flexibility and performance [Agarwal, (2022), pp. 117-144], [Mustățea, (2019), pp. 9-11].

   b. **Polyhydroxyalkanoates** (PHA) are a biodegradable plastic made by bacteria using food

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waste like oils, starch, and sugars. Like synthetic plastic, it is mechanically strong but breaks down indisputably, making it a promising alternative to synthetic plastic for short-term food packaging. Some types of PHA are hard and brittle, while others are soft and stretchy [Agarwal, (2022), pp. 117-144], [Mustățea, (2019), pp. 9-11].

Market size of biodegradable food packaging in India:

High consumer awareness and the government initiative toward a plastic ban are helping the biodegradable market to grow in different regions. The rise of online food delivery, the growth of fast food restaurants, and changing customer preferences for eco-friendly packaging are the factors nourishing the market growth. Local manufacturers and partnerships with global food retailers are also helping this market expand further. According to the report published by KEN RESEARCH, the biodegradable food packaging market was valued at USD 3.09 billion in 2024 in India. Major metropolitan regions like Mumbai, Delhi, and Bangalore have dominated the market.

Table 1: Recent companies in India active in biodegradable packaging.

(Data is obtained from the official websites of the respective companies.)

Sr. No.	Company Name	Year Founded	Location in India	Products	Raw Material	Website
1	Ecoware	2009	New Delhi	Cups, Trays, Areca Bowls, and Plates	Seaweed and Bagasse – the pulp of sugarcane.	ecoware.in
2	Pappco Greenware	2011	Mumbai	Compostable Tableware	Bagasse – the pulp of sugarcane.	pappcoindia.com
3	CHUK	2017	Uttar Pradesh	Compostable Plates and Spoons	Bagasse – the pulp of sugarcane.	chuk.in
4	Thooshan	2010	Tamil Nadu	Edible and Biodegradable Plates and Straws	Wheat bran, Rice bran, and Rice husk.	thooshan.com
5	Biogreen	2008	Karnataka	Premium Disposables Cutlery, Packing, Bags, and Pouches	corn starch, bagasse, and vegetable waste, along with recycled ocean plastic as a raw material	biogreenbags.com
6	Saattvic Ecocare	2016	Mumbai	Eco-friendly Packaging and Single-use take-out containers	wooden and bagasse (the pulp of sugarcane)	saattvicecocare. in

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7	Greenx Tableware	2016	Gujrat	Plates and Cutlery, Clamshell Container, Bowls and Trays	Bagasse – the pulp of sugarcane.	Greenxtableware.com
8	Cosmos Eco Friends	2017	Haryana	Plates, Cups, and Trays, Disposable Soup Cups	Corn starch.	cosmosecofriends.in
9	Dinearth	1998	Mumbai	Disposable Plates and Bowls, Trays and Containers	Bagasse – the pulp of sugarcane.	dinearth.com
10	Natur Trust	1978	Uttar Pradesh	Biodegradable Bags	Starch, PLA (polylactic acid), and PBAT (Polybutylene Adipate Terephthalate).	naturtrust.com
11	Zerocircle	2020	Pune	food packaging boxes, containers, and trays	seaweed	zerocircle
12	Aurapha Private Limited	2021	Tamil Nadu	food packaging, straws, spoons, forks, cups, and plates.	PHA (polyhydroxyal kanoate)	Aurapha
13	Bhagirath Industries	2019	Gujarat	PLA medical implants, PLA bioplastic polymers, commercial	PLA (polylactic acid)	Bhagirath

Government initiatives and regulatory support are significantly helping the northern region, like Delhi and surrounding places, while the tech-savvy population and booming e-commerce sector are helping the southern region, like Bangalore. As a part of the Swachh Bharat Mission 2.0, introduced in 2021, the Indian government has primarily focused on biodegradable packaging. The initiative aims to phase out single-use plastics in urban areas by 2026, with an estimated budget of INR 1.41 lakh crore dedicated to waste management and sustainable solutions.

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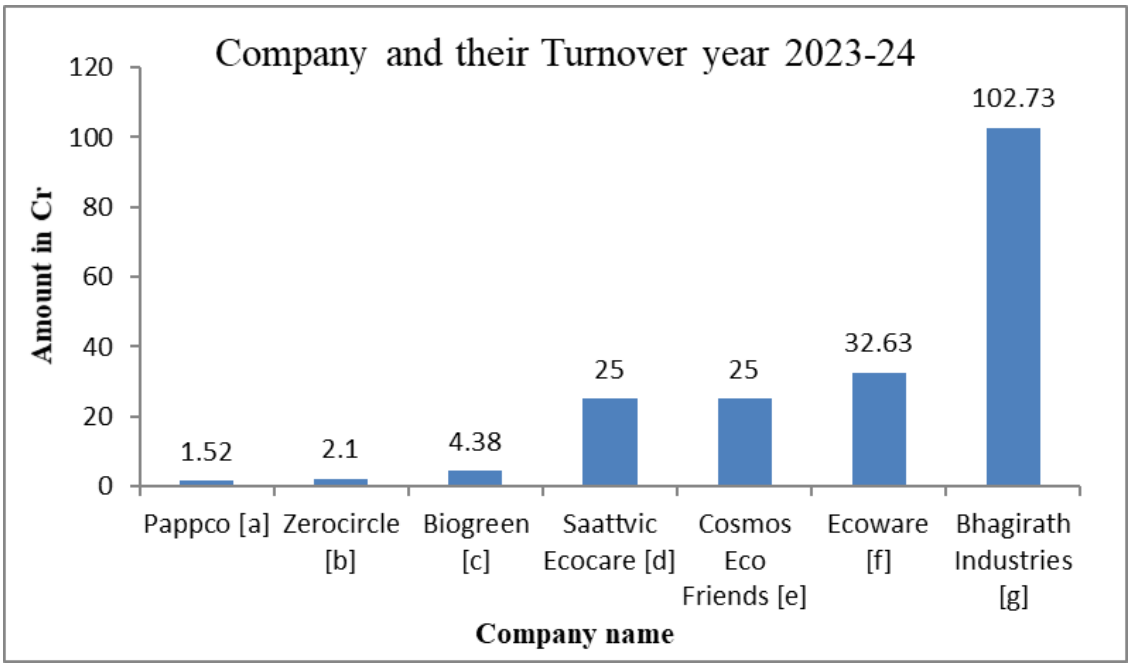

Fig.2 Different companies and their annual turnover (2023-24).][a, b, c, d, e, f, g]

Apart from the private companies, several entrepreneurs have also made an appearance. SPS Kalyan Enviro Power is a Tamil-based Firm established by Kalyan Kumar. He has invented a machine that converts agricultural waste like husk, bran, and straw into products like tea cups, juice and wine cups, food containers, ice cream bowls, spoons, and many more. A Bangalore-based firm, "Aecoz", which is owned by a family, has managed to produce and sell more than 4.5 crore biodegradable products like cups, bowls, containers, lids, boxes, and more. It has been anticipated that they have not only provided an alternative to microplastic and single-use plastic but also prevented the use of over four lakh kilograms of plastic. They have successfully grabbed clients like Lulu Hypermarkets, MTR, Milano Ice Creams, Magnolia Bakery, and Ritz-Carlton, which enabled them to reach a whopping revenue of 5.2 crore INR in 2024.

Milano ice creams (Italian gelato company) have been using Aecoz cups for the last three years

Challenges and research in improving properties of biodegradable materials: Biodegradable packaging materials help keep food fresh for a longer time. It is made from renewable plant sources or agro-industrial waste, reducing environmental impact. However, to use biodegradable materials in packaging, one has to consider their limitations, such as cost effectiveness, mechanical strength, availability, and durability of polymer or fiber. Since biodegradable

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materials are made with new technology and in small amounts, they are more expensive than their synthetic counterparts. [Panou, (2023), pp. 1176][Cheng, (2024), pp.70-83] Some materials, like PLA, can't handle high temperatures and may become brittle or lose shape. [Mustățea, (2019), pp. 9-11] Materials such as Alginates and gelatin don't block oxygen and moisture well, which can spoil food fast.[Cheng, (2024), pp.70-83] Some biodegradable plastics, such as PHA, break easily and aren't flexible enough for all packaging needs. Some materials, like Soy protein, Lipids, and PHA, can be hard to shape.[However, researchers are trying to minimize the space between present and desirable properties of these biodegradable polymers.

A newly modified method suggests that blending starch and polyvinyl alcohol (PVA) in the presence of lactic acid can make PVA biodegradable, effectively. These modifications are ideal for producing biodegradable food films that can serve as packaging for various foods, helping to increase their shelf life.[Negim (2014), pp. 263] Incorporating torrefied biomass as a bulk-loading filler in polylactic acid (PLA) composites boosts chemical properties, hydrophobicity, and compatibility.[Choi, (2025), pp. 51] Also, this method has tremendously increased the production capacity of PLA as depicted in Fig. 3 [European bioplastics, (2022)]

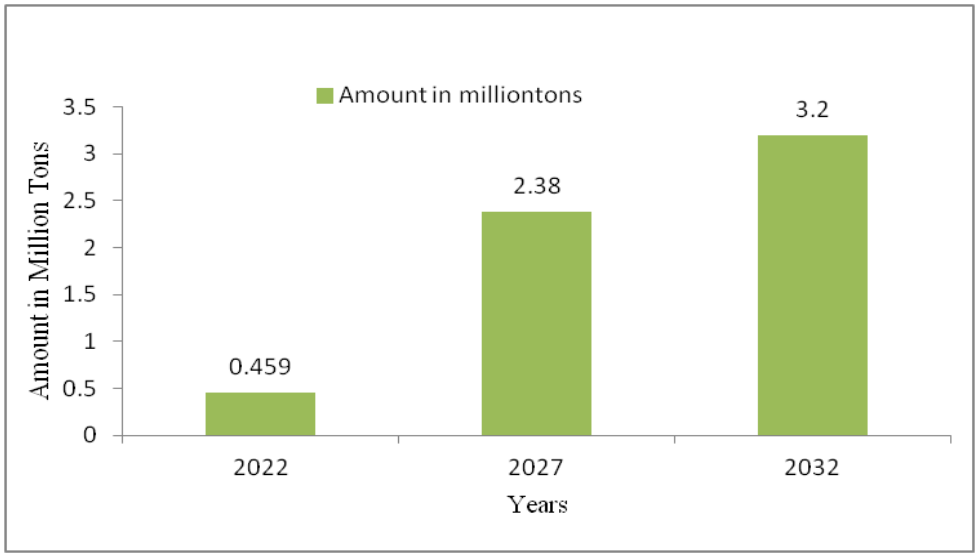

Fig. 3: Year-wise growth forecast in the production capacity of PLA

PBS, a synthetic biodegradable polymer, when blended with 10% 16-hydroxyhexadecanoic acid (16HHD) and poly(ε-caprolactone) (PCL), enhances its biodegradability in marine environments. That leads to minimizing sea pollution and protecting aquatic life.[Suzuki, (2024) pp. 228] After several years of research, Thooshan, a biodegradable manufacturer in Tamil Nadu, has developed a way to manufacture tableware that is 100% biodegradable. The company excels in edible plates, bowls, and cups, based on raw materials like wheat bran.[Thooshan group, (2025)]

Conclusion:

Online food delivery is one of the prime sectors of the Gig economy. With the ever-increasing trend of take-away food, especially in urban areas, there is a parallel growth in the demand for food packaging materials. Plastic-based food packaging material is traditionally used. However, considering the environmental and health threats, more and more emphasis is given to sustainable and green alternatives such as biodegradable plastic. As a result, the demand for biodegradable packaging is increasing distinctly. The government has also motivated biodegradable food packaging businesses

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under the Swachh Bharat Mission. The revenue generated through all the food packaging industries in India that use biodegradable material is estimated at around USD 3.09 billion in 2024.

The major companies like The Mend, Pappco Greenware, Cosmos Eco Friends, and Dinearth offer green alternatives to the traditional plastic packaging. Apart from large companies, several entrepreneurs have also made an appearance. For example, Bangalore-based firm "Aecoz" has succeeded in producing and selling more than 4.5 crore products like cups, bowls, containers, lids, boxes, and more. It is estimated to generate a revenue of over 5.2 crore INR in 2024. With the increasing population and the growing online food culture, the demand for sustainable, environment-friendly, biodegradable packaging material is expected to show a steep rise subsequently. Although the share of biodegradable materials in the food packaging market is very low in today's scenario, a massive amount of employment generation in this field in the future is possible, owing to increased awareness regarding the adverse impact on health and the environment caused by traditionally used synthetic plastic.

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