



# VIT<sup>®</sup>

## Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

### A Project Report On Sustainability of Bioplastics

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Introduction to Innovative Project(PHY1901)

*Under the Guidance of*

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## **Introduction**

Plastics, as we know, are a mix of materials from a wide range of organic compounds. These materials can be of several different types, depending on the compounds used to make them. However, these plastics which are being produced in such a widespread manner can have an adverse effect on the environment, since they do not decompose in soil easily even over vast periods of time, and when burned release noxious gases in the atmosphere.

One proposed solution to this problem is to provide a replacement for regular plastics, in the form of more environmentally friendly bio-plastics, derived and produced from various types of biomass sources. These have a longer lifespan and are easily degradable.

In this project we have explored the idea of using bioplastics as a replacement for regular plastics.

# **Plastics**

## **Traditional Plastics**

Plastics are a wide range of synthetic or semi-synthetic materials that use polymers as a main ingredient with a wide range of other properties, such as being lightweight, durable, flexible, and inexpensive to produce, which has led to its widespread use. Most modern plastics are derived from fossil fuel-based chemicals like natural gas or petroleum.

### **Common Plastics Types**

- Polyamides (PA) or (nylons)
- Polycarbonate (PC)
- High-density polyethylene (HDPE)
- Low-density polyethylene (LDPE)
- Polyethylene terephthalate (PET)
- Polyvinyl chloride (PVC)
- Polypropylene (PP)
- Polystyrene (PS)



## Properties of Plastics

- ❖ Durability - Plastics generally possess sufficient durability, provided they offer sufficient surface hardness.
- ❖ Strength - Plastics are sufficiently strong and can be used for load bearing structural members. The strength of plastics can further be increased by reinforcing them with various fibrous material.
- ❖ Weather resistance -The plastics, prepared from phenolic resins, are only good in resisting weather effects. Certain plastics are seriously affected by ultraviolet light.
- ❖ Other physical properties include hardness, density, tensile strength, thermal resistance, and glass transition temperature.

## How Plastics are made

Plastics are made from raw materials like natural gas, crude oil or plants, which are refined into ethane and propane. Ethane and propane are then treated with heat in a process called “cracking” which turns them into ethylene and propylene. These materials are combined together to create different polymers.



## How Plastics are Harmful

- ❖ Marine life - Natural Environment estimates that approximately 100,000 sea turtles and other marine animals die every year because they get strangled in bags or mistake them for food.



- ❖ Public health effects- Toxic chemicals leach out of plastic and are found in the blood and tissue of nearly all of us. Exposure to them is linked to cancers, birth defects, impaired immunity, endocrine disruption and other ailments.
- ❖ Wildlife - Millions of animals are killed by plastics every year, from birds to fish to other marine organisms. Nearly 700 species, including endangered ones, are known to have been affected by plastics. Nearly every species of seabird eats plastics. Most of the deaths to animals are caused by entanglement or starvation. Seals, whales, turtles, and other animals are strangled by abandoned fishing gear or discarded six-pack rings. Microplastics have been found in more than 100 aquatic species, including fish, shrimp, and mussels destined for our dinner plates.





- ❖ Land Pollution- About 80% of plastic waste present at sea originates from land-related sources. Dumping of plastics on land or landfilling plastics leads to abiotic and biotic degradation of the plastics, where plastic additives (eg. stabilizers, harmful colorant moieties, plasticizers and heavy metals) can leach and eventually percolate into various aspects of the environment, thereby causing soil and water contamination.



- ❖ Plastic never goes away - Plastic is a material made to last forever, yet 33 percent of all plastic - water bottles, bags and straws - are used just once and

thrown away. Plastic cannot biodegrade; it breaks down into smaller and smaller pieces.



- ❖ **Pollutes groundwater :** There are thousands of landfills in the United States. Buried beneath each one of them, toxic chemicals from plastics drain out and seep into groundwater, flowing downstream into lakes and rivers.



# **Bioplastics**



## **Introduction**

Bioplastics are plastic materials produced from renewable biomass sources, such as vegetable fats and oils, corn starch, straw, woodchips, sawdust, recycled food waste, etc. Bioplastic can be made from agricultural by-products and also from used plastics by using microorganisms. Common plastics, such as fossil fuel plastics are derived from petroleum or natural gas. Not all bioplastics are biodegradable nor biodegrade more readily than commodity fossil-fuel derived plastics. Bioplastics are usually derived from sugar derivatives, including starch, cellulose, and lactic acid. As of 2014, bioplastics represented approximately 0.2% of the global polymer market (300 million tons).



## Properties

- ❖ Biopl Bio-based and durable (non-biodegradable) bioplastics are made using renewable resources but are designed to have a longer life span (for example, carpet fibers and interior car panels). Using renewable resources makes these materials more sustainable. Also, using them to replace metal components in vehicles has the advantage of reducing vehicle weight, which increases fuel efficiency.
- ❖ Petrochemical-based and biodegradable bioplastics are some petrochemical-based plastics that can be biodegraded by the microbes in the soil, compost or oceans.
- ❖ Bio-based and biodegradable bioplastics are made using renewable resources, such as plant biomass, and will biodegrade under certain environmental conditions. These materials are suitable for disposable items, such as packaging, drink bottles, single-use food containers and cutlery. They are more sustainable because they save fossil fuel resources and, if disposed of appropriately, support further plant growth.



## How Bioplastics are made

Bioplastics are made by converting the sugar present in plants into plastic. In the United States, that sugar comes from corn. Other countries use sugar cane, sugar beets, wheat, or potatoes. This makes bioplastics renewable and better for the environment than conventional plastics. Two types of bioplastics are now produced in large quantities. They are called polylactide acid (PLA) and polyhydroxyalkanoate (PHA).



Polylactic acid (PLA) is a transparent plastic produced from maize or dextrose. Superficially, it is similar to conventional petrochemical-based mass plastics like PS. It has the distinct advantage of degrading to nontoxic products. Unfortunately, it exhibits inferior impact strength, thermal robustness, and barrier properties (blocking air transport across the membrane). PLA and PLA blends generally come in the form of granules with various properties and are used in the plastic processing industry for the production of films, fibers, plastic containers, cups and bottles. PLA is also the most common type of plastic filament used for home fused deposition modeling.

The biggest producer of PLA is NatureWorks, a company located in Blair, Neb. There, corn kernels are milled, a chemical substance called dextrose is extracted, and dextrose is fermented by bacteria or yeast in big vats. The result is lactic acid), which acts as a repeating unit to make PLA.



## Advantages of Bioplastics

- ❖ The primary benefit and advantage in using bioplastics is their capability to improve the environmental impact of a product.
- ❖ Reduction of greenhouse gas emission & Saving fossil fuels.
- ❖ Possibility of using a local resource & Reclamation of by-products.
- ❖ Bioplastics are biodegradable and compostable.
- ❖ Bioplastics are made from plant raw materials instead of petroleum oil, the raw material used to make conventional plastics.
- ❖ Plant raw materials are renewable and sustainable unlike oil which is a limited and finite resource.

- ❖ The carbon footprint of manufacturing bioplastics is reportedly 75% lower than that of PET and PS alternatives i.e. their manufacture is kinder to the environment.
- ❖ Bioplastics are non-toxic and won't leach chemicals into food. According to a study conducted by The National Center for Biotechnology Information in America; plastics (including BPA free plastics) leach estrogen-like chemicals into food.
- ❖ There are a variety of zero waste end of life options for bioplastics. Bioplastics can be recycled; they can be cleanly incinerated and industrially composted. This makes bioplastics a great material for food packaging as used packaging does not require cleaning since food and packaging can be composted or incinerated together. An additional benefit of composting is that nutrients from food waste are returned to soil to nurture new plants, improving soil fertility and food security.
- ❖ The main ingredient of bioplastics is Starch. Again, this is an advantage of bioplastic that its main ingredient is Starch which is very cost efficient and easily available. We can also derive starch from the waste products of our household such as potato, peas, beans, pasta, noodles, rice, corn, grains, pulses etc.

## **Some disadvantage of Bioplastics**

- ❖ Growing demand for bioplastics creates competition for food sources, contributing to the global food crisis. This is a misleading argument commonly used against bioplastics. The raw material for bioplastics is an industrial-grade corn which is not grown for human consumption. Recent technological developments in the bioplastics industry have shown that it is

possible to make biodegradable bioplastics from hemp, seaweed and other plants. As the market grows, we can expect to see many new innovative production approaches.

- ❖ Bioplastics won't biodegrade in a landfill. Unfortunately landfills remain the last stop for many plastics. We believe the benefits of a lower carbon footprint to produce bioplastic products and the fact that they offer the potential for composting as a new way of achieving zero waste still sets them apart. There are arguments that should bioplastics end up in nature they will break down into non-toxic components. This requires a specific set of conditions, which are not always available, to be in place.
- ❖ Bioplastics encourage people to litter more. We hope not and do not encourage littering with our products. (Don't let us catch you!) Littering is a human behaviour, which requires education, raised awareness, a good infrastructure to be reduced.
- ❖ Bioplastics contaminate plastic recycling streams. Most bioplastics are compatible with existing recycling systems. Bioplastic PET is compatible with PET recycling streams and bioplastic PE is compatible with the PE recycling stream. Recycling systems are excellent at separating different materials and need to be because there are many different types of plastic, and they all need to be separated before they have any chance of being recycled.
- ❖ Bioplastics are not the answer to marine litter. We agree. You can read why bioplastics are not the answer to marine litter [here](#).



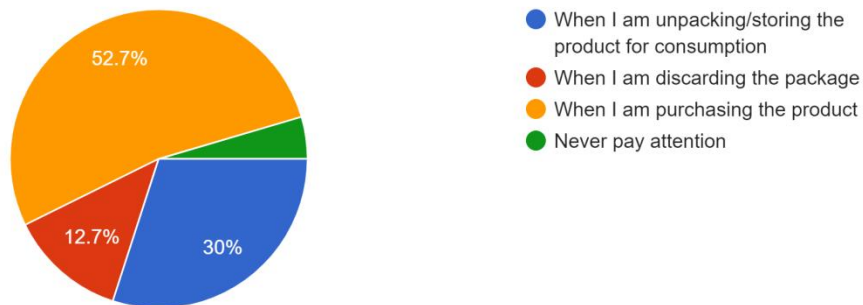
# Survey on Bioplastics

## Objective of the Survey

In this survey, we have aimed to understand how people perceive plastics, how they view bio-plastics, how much they understand about bioplastics, their properties and how they are made. We have started by asking questions about how they use plastics in their day - to - day life, and how much they understand about the impact of such plastics.

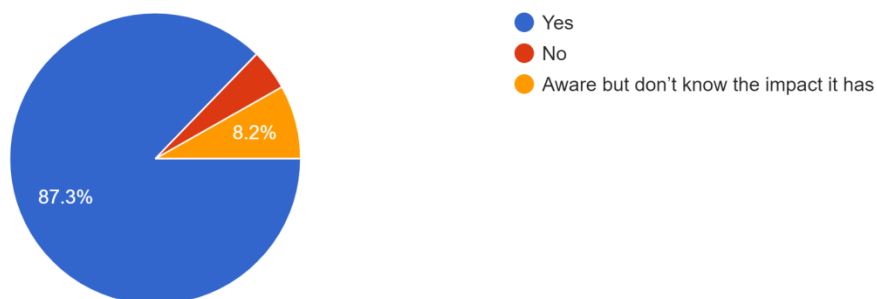
When do you pay attention to the package of the product you purchase ?

110 responses



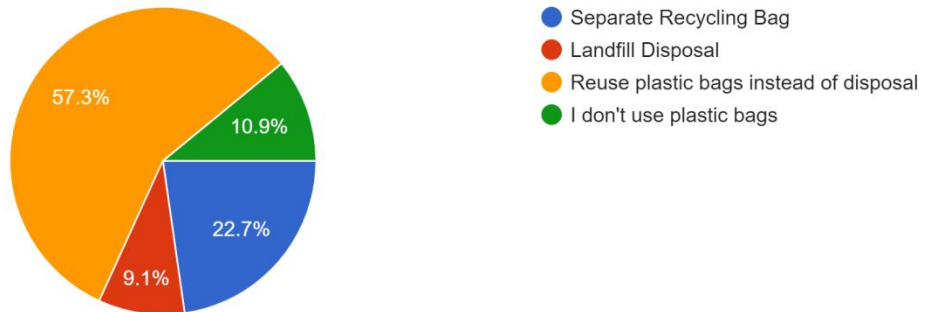
Are you aware of plastic pollution and the impact it has on the environment ?

110 responses



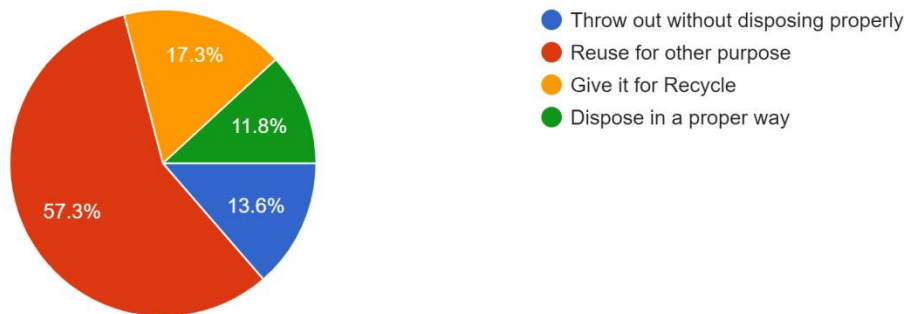
### How do you dispose plastic bags from Home ?

110 responses



### What you do with unused plastic products?

110 responses



### Are you aware of recycling of plastics in methods like building roads?

110 responses

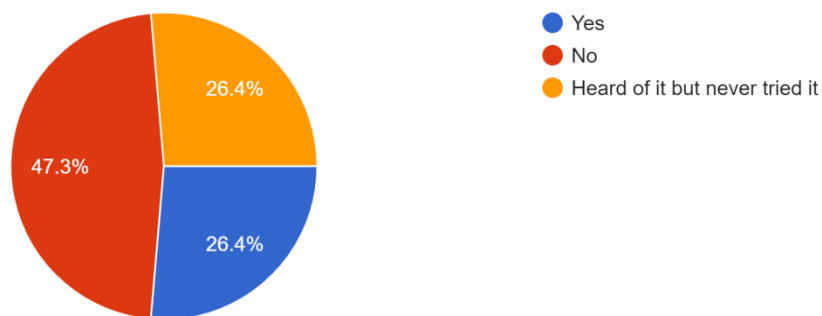


## Bioplastic Awareness

In this section of the survey, we have asked people whether they have used bioplastics before, and how aware they are about the properties of bioplastics and how they compare to regular plastics discussed earlier.

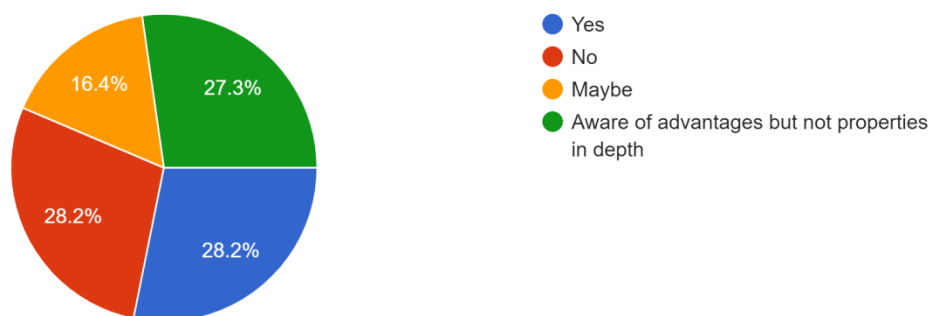
Have you ever tried bioplastic packaging while purchasing any product?

110 responses



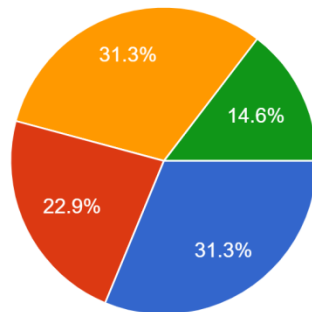
Are you aware of the properties of bioplastics and its advantages?

110 responses



Which one of these drawback of Bioplastic you are aware of ?

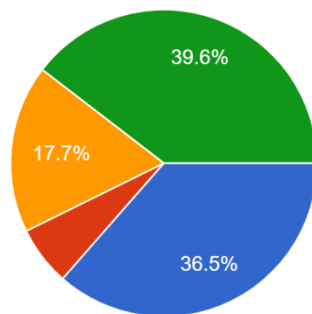
96 responses



- They may decompose in landfills to produce methane gas
- They may require additional factors like UV rays and extreme temperature to be readily decomposed.
- If mixed with regular plastics, it becomes very difficult for them to be decomposed properly.
- Since they are a novel idea, they may use up more resources during the pro...

Which one of these advantage of Bioplastic over synthetic plastic you are aware of ?

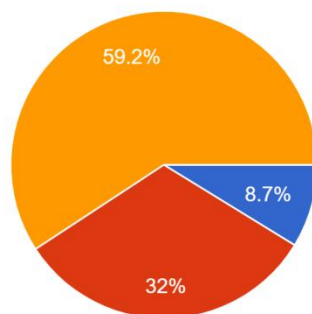
96 responses



- Bioplastic polymers are naturally occurring and don't have the carbon footprint of synthetic plastics
- Saves energy during production
- Doesn't contain health-damaging additives like phthalates or bisphenol-A
- They are non-toxic, degradable and recyclable

Do you know how bioplastics are made?

103 responses



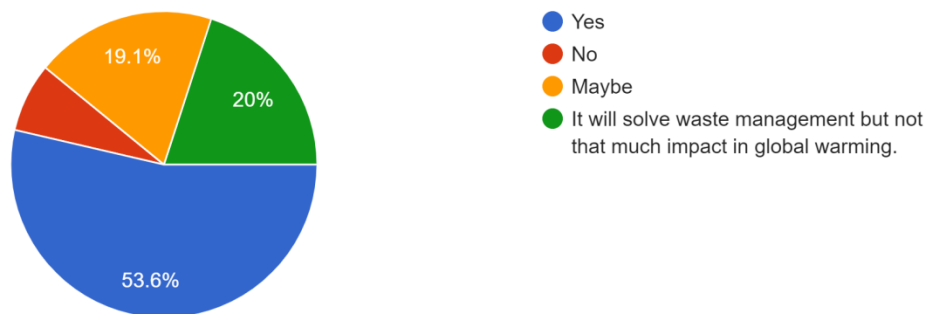
- Yes, I am aware and have made them.
- Yes, I am aware, but have not made them.
- Not aware of how to make them

## Impact of Bioplastic

In this section of the survey, we have asked people what they think the impact of bioplastics will be when they are used to replace regular plastics, and how this change can be brought about.

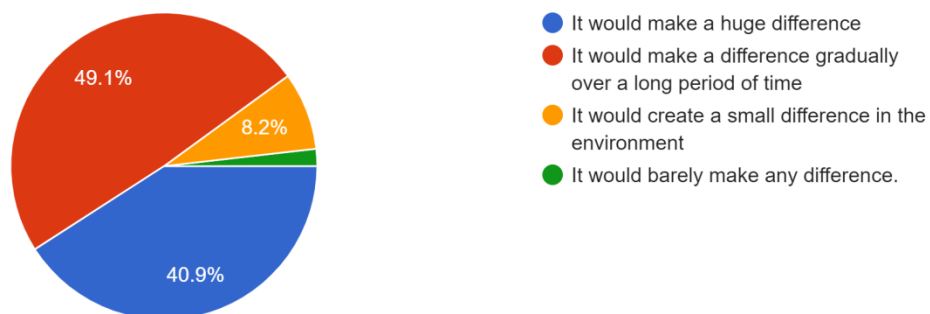
Do you think bioplastics will help in solving global warming, climate change, and waste management ?

110 responses



How do you think, a large chunk of the population switching from regular plastic to bioplastics would impact the environment?

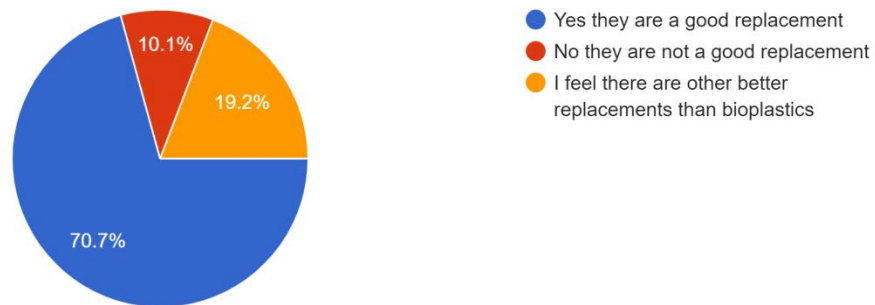
110 responses





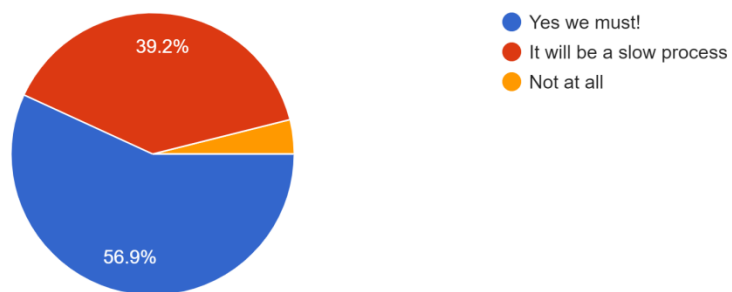
Do you feel bioplastic are a suitable replacement for regular plastics ?

99 responses



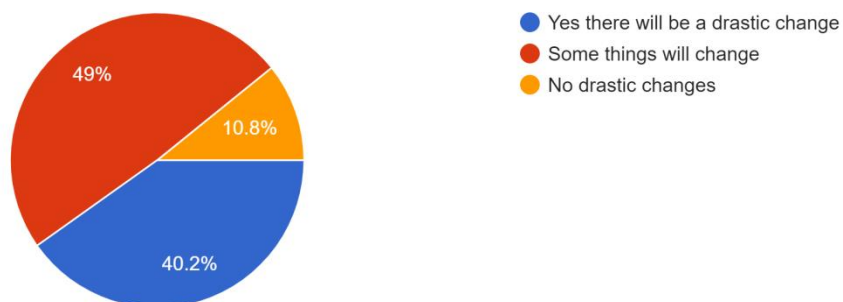
After learning about Bioplastics, do you feel we must change from plastics to bioplastics immediately?

102 responses



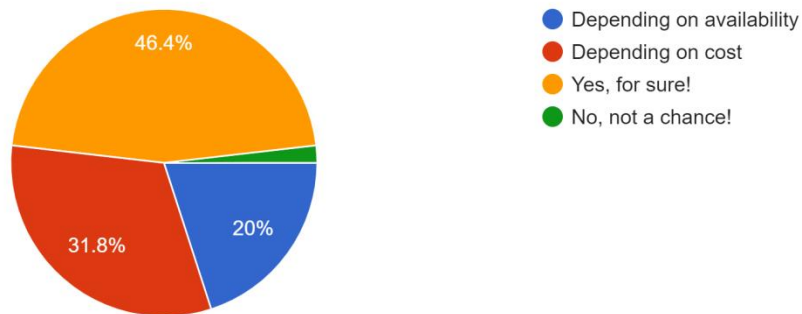
Do you think changing to bioplastics will cause changes in our daily livelihood ?

102 responses



Are you willing to switch from regular plastics to bioplastics to be environment friendly ?

110 responses



## Uses of Bioplastics & Our Proposals

Permanent bioplastics, such as polythene manufactured from sugar cane, can provide a near-perfect substitute for oil-based equivalents in products where durability and robustness is vital. Plastics made from biological materials generally need far smaller amounts of energy to manufacture but are equally recyclable. They use fewer pollutants during the manufacturing process. Per tonne of finished products, the global warming impact of the manufacture of bioplastics is less, and often very substantially less than conventional plastics.

Some uses are as follows:

- ❖ Bioplastic packaging
- ❖ Consumer electronics
- ❖ Food service

- ❖ Medical applications
- ❖ Aerospace and Automotive
- ❖ Disposable housewares
- ❖ Construction activities

## Bioplastic packaging

In relation to the production of packaging, conventional plastics are being replaced by bioplastics at a rapid pace. There's a big demand for bioplastic packaging and it is the largest segment of the European bioplastic market – estimated at around 44% of 2.05 million tones in 2017.

Bioplastics provide an alternative approach to packaging and are a real solution to the need for a reduction in conventional plastic use and waste. Plant based polymers are able to fully compost at the end of their useful life.



## Consumer electronics

The electronics industry has made big strides in tackling its environmental impact, largely through producing more energy efficient devices and through more efficient recycling options for electronic waste. Most recently it has started to address the sustainability of the materials it uses in its products. Most of the E waste can be reduced.

Obviously, the nature of electronics is more complex than packaging and because plant derived bioplastics are generally processed at a lower temperature than traditional products – in the past there were issues in relation to poor temperature resistance. This caused a bit of a barrier for electronic applications. However new technology has produced some big advancements in this area – improving temperature resistance – as a result bioplastic is now a suitable alternative for many components produced by the electronics industry.



## Food service

Grabbing food and drinks on the go is increasingly popular for people with busy lifestyles but with it comes increased waste – that needs to be disposed of responsibly.

Bioplastics are helping to reduce the impact of this waste on the environment and are being used in applications such as thermoformed coffee cup lids, disposable cutlery and plates along with food containers of all shapes and sizes.



## Medical applications

PermaNontoxic biodegradable bioplastics sutures, commonly referred to as stitches, are now being used by medical professionals in hospitals and surgeries. They are easy to sterilize, robust and remain in place until the tissue has healed at which time, they are dissolved by the body leaving no marks behind.



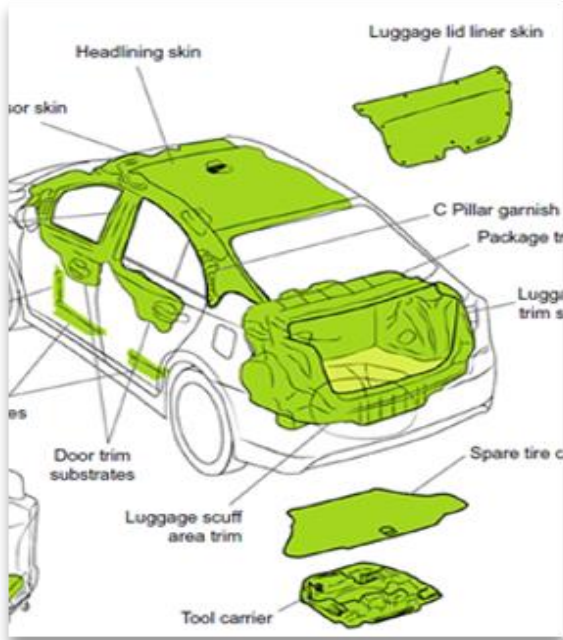
Biodegradable plastics are also being used for medicine. For example, pins, tacks and screws which are used to help bones heal and during reconstructive surgery are being produced with bioplastics. Containers for tablets and creams can also be produced using bioplastic. As with standard medical products bioplastic components can be manufactured.



## Aerospace and Automotive

PermaTransport is considered to be one of the greatest contributors to carbon emissions on a global scale. The aerospace and auto industry are examining how they can design more sustainable vehicles that cause less of an impact.

The good news is that bioplastics can perform to the same standards as their traditional plastic counterparts. We mentioned earlier that plastic components used in electronic products need to have strong temperature resistance and this is also true of components produced for the aerospace and the automotive sectors. So now that high performance is possible in terms of temperature control – with bioplastic – we are going to see a big leap in the use of bioplastic components in these sectors.



## Disposable housewares

Disposable housewares made from biodegradable plastics are now seen as marketable options, replacing traditional plastics such as polystyrene and polyolefin. Housewares such as kitchen tools and utensils, washable storage containers and cups, bathroom accessories, toys, hangers, and hooks are now being produced using biodegradable plastics. One such example is the Fantastic Beach toys by Zoe" b Organic which are made with Mirel bioplastic from corn.



## Construction activities

- ❖ The opportunity to use these Plastic Waste for construction applications will not only conserve the marine environment but reduces the overall environmental threat the production of these plastics imposes. In addition, the possible use of Plastic Waste for construction applications will help the construction industry to achieve its sustainability objectives.
- ❖ The construction industry is a promising sector where Plastic waste can be beneficially used for various applications, mainly because it is the largest industry in different economies and the highest consumer of raw materials. It can be used as a civil construction material in the form of aggregate in cementitious and asphalt mixtures, filler, insulation, etc.
- ❖ However, despite the huge potential for the application of Plastic in construction, its use and development are still very limited. However, in order to use Plastic waste for construction purposes, it must satisfy both the mechanical and durability properties of the intended application. In addition to the performance of it as a construction material, it should be cost-effective

and sustainable to encourage its use over other types of materials. The ability to incorporate various materials during the mixing process of cementitious composites has opened a pathway for the incorporation of various materials into it. Several types of waste materials have been incorporated into the cementitious composite as a binder and aggregate.

- ❖ India is the country where there appears to be the most experience with using waste plastics in road construction. Since 2002, waste plastic has been used to construct more than 2500 km of roads which were reportedly functioning well without potholes, ravelling and rutting up to ten years later.

If companies are looking for construction materials that are efficient, durable and money-saving, plastics are incredibly promising. More staggering news comes from not only using plastics in construction, but plastics that have been recycled. Not only does this follow the trend of efficient energy, but it also saves space in landfills and reduces costs to an even lower level. When recycled plastic is blended with virgin plastic, costs can be lowered because there is a lower amount of brand-new plastic being used and produced. Using recycled plastic can also help save on the costs of other materials, such as wood and slate.

Main Uses in construction industry:

1. Roofing tiles
2. Concrete
3. Indoor insulation
4. PVC windows
5. Bricks
6. Flooring tiles
7. Fences etc

# **Conclusion**

- ❖ From what we have observed by doing this project, we see that, in order to mitigate the pollution crisis caused by plastics, bioplastics can be used as an alternative, decomposable method.
- ❖ However, it is necessary for people to understand the properties and limitations of bioplastics.
- ❖ The change to bioplastics will be a gradual one as people are not yet completely open to moving to these new options.
- ❖ Additionally, the energy used in producing bioplastics must be moderated and understood if we are to keep the environmental impact at a minimum.

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