

## BIOPLASTIC TOWARDS REDUCING CARBON FOOTPRINT AND ENHANCING HUMAN HEALTH IN INTERIOR ARCHITECTURE

### البلاستيك الحيوي نحو تقليل البصمة الكربونية وتعزيز صحة الإنسان في العمارة الداخلية

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### ABSTRACT

Although plastic is a light, flexible material, it's taken into consideration as one of the reasons for environmental pollution from fossil fuels. It increases the carbon footprint of what's called plastic pollution. On the other hand, numerous studies have mentioned the opportunity of degrading plastics and returning them to nature. The study aims to discuss what bioplastics have come to be that could assist reduce the carbon footprint of the environment, as bioplastics emit lower greenhouse fuel line emissions than traditional plastics over their lifetime. The study follows the inductive analytical method to how bioplastics are beneficially utilized in interior architecture, lowering carbon emissions and their effect on human health associated with their performance. Then it indicates how bioplastics can fit the Egyptian environment. Finally, the research ends with conclusions and suggestions that show the significance of the use of bioplastics as a future biomaterial in interior design.

### KEYWORDS

Bioplastic; Carbon footprint; Human health in interior architecture.

### المخلص

على الرغم من أن البلاستيك مادة خفيفة ومرنة ودائمة، إلا أنه يعتبر أحد أكبر أسباب المشاكل البيئية الناجمة عن الوقود الأحفوري. حيث إنه يزيد من البصمة الكربونية لما يعرف بالتلوث البلاستيكي. من ناحية أخرى، ناقشت العديد من الأوراق البحثية البلاستيك القابل للتحلل إمكانية إعادة استخدامه إلى الطبيعة. يهدف البحث إلى مناقشة ماهية المواد البلاستيكية الحيوية التي يمكن أن تساعد في تقليل البصمة الكربونية للبيئة، حيث تنتج انبعاثات غازات الاحتباس الحراري أقل بكثير من اللدائن التقليدية على مدار حياتها. يتبع البحث النهج الاستقرائي التحليلي لكيفية استخدام البلاستيك الحيوي بشكل مفيد في تصميم العمارة الداخلية، ومدى تقليل انبعاثات الكربون وتأثيرها على صحة الإنسان، ثم يقترح كيف يمكن للبلاستيك الحيوي أن يتناسب مع البيئة المصرية. أخيراً، تنتهي الورقة باستنتاجات وتوصيات تثبت أهمية استخدام البلاستيك الحيوي كمادة بديلة في تصميم الفضاء الداخلي في المستقبل.

### الكلمات المفتاحية

البلاستيك الحيوي؛ البصمة الكربونية؛ صحة لإنسان في العمارة الداخلية.

## 1. INTRODUCTION

Plastic is one of the most widely used materials in a variety all over the world. It has become an essential part of human consumption in many fields, the most important of which is its many uses in interior architecture. However, traditional plastics are made from crude oil and non-renewable resources. It creates many environmental concerns according to the carbon footprint. Whether in the surrounding environment or the interior environment of the buildings, this issue affects the general health of the occupants of the interior space physically, psychologically, and mentally, which affects their behavior and activity. It is also one of the most massive points of conflict with the principles and standards of sustainability, so the success of the widespread adoption of bioplastics depends on the design, product measurements, and addressing the concerns of bioplastic consumers.

### 1.1 The Research Problem

The research problem lies in several points:

- Traditional plastic causes a high carbon footprint that negatively affects environmental sustainability and it increases from a consumption perspective and the net traded GHG emissions of plastics. Figure 1.
- While a high carbon footprint affects the interior space user mentally and psychologically, it affects their behaviour and ability to produce and interact.
- The limited use of bio-plastics in the interior architecture of Egypt and its use restriction to packaging and small consumer products.

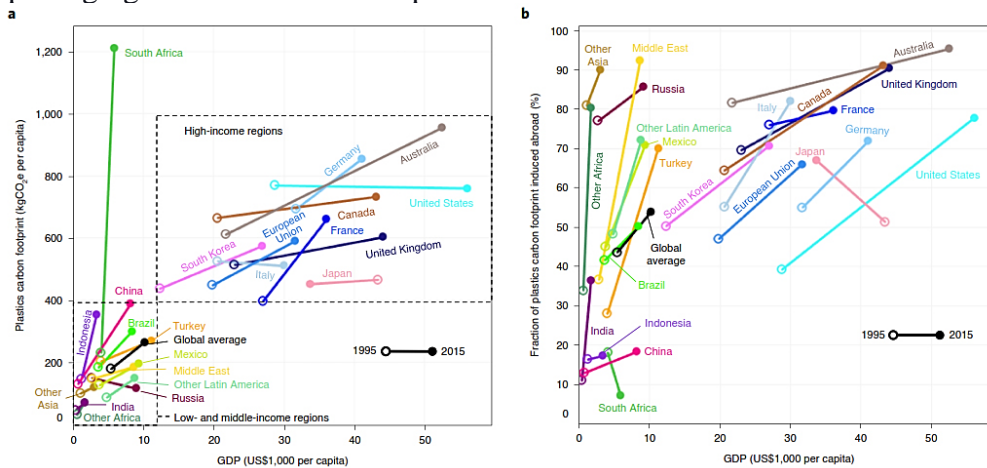


Figure 1: The role of imports and countries' plastics-related carbon footprints between 1995 and 2015. Changes in the carbon footprints of plastics per person from a consumption standpoint.

b. The percentage of plastics' carbon footprint and their net traded GHG emissions have changed (Cabernard, L. et al., 2022)

### 1.2 Objectives

The main aim of the research is to clarify how to reduce the carbon footprint of plastic as a common material used in interior design to avoid users' mental disorders or psychological desires in the future. So, the objectives are shown in the following points:

- Explore what bio-based plastic has added to the field of interior design in terms of reducing carbon footprint in interior design.
- Explore how using bioplastic can affect the interior occupant's health positively.

- Attempt to devise a new role for using bioplastic as bio-based treated material in interior architecture in Egypt.

### 1.3 Methodology

This paper presents a study of bioplastic and its relationship to reducing its carbon footprint to preserve the health of the space occupants, as well as the most essential features that qualify it to excel over traditional plastic as a manufacturing material for the components and requirements of interior architecture. So, the research follows an analytical inductive methodology for some sustainability criteria in interior architecture, the ability to reduce the carbon emissions within the interior space, the extent of its use as an alternative future material, and the extent to which this affects performance improvement to ensure the health of the occupants of the space. This will be shown through the following points:

- Identify bioplastic as an alternative bio-based material and its impact on carbon footprint.
- Analysing past experiences of utilizing plastics and bioplastics in interior architecture to point out the impact on interior design and human health.
- Finding out the impact of Carbon footprint on human health.
- Analysing selection criteria in interior architecture for sustainability to explore the benefits of using bioplastics.
- Finally, the paper provides an added suggestion for improving bioplastic approaches in interior architecture in Egypt.

## 2. TRADITIONAL PLASTIC HAS DRAWBACKS

After the packaging industry, the construction industry is the second industry to make the most of plastics. Plastics have always been seen as an integral part of the building process, but many players in the industry are aware of their negative impact on the environment.

Although plastic is cheap to produce, easy to obtain and very useful, it has many drawbacks. Its detrimental effects are of great concern as follows (Vedantu., 2022):

- Potentially hazardous compounds such as stabilizers and colorants are added during the production of plastics.
- Most plastics are not biodegradable and can take a long time to decompose once landfilled.
- Both manufacturing and recycling plastics produce toxic gases and residues that pollute the air, water, and soil.
- Plastic creates many fire hazards.

## 3. BIOPLASTIC AND BIO-BASED PLASTIC

According to Technical Report 15392, prepared in August 2009 by Technical Committee CEN/TC 249 of the European Committee for Standardization, "bio-based plastics" are plastics derived from biomass, and that means non-fossil, biodegradable organic matter of plant, animal or microbial origin. It considered a renewable resource as long as its utilization rate does not exceed replenishment by natural processes.

However, "Bioplastic". The bio-plastic prefix "bio-" is used to denote the material's "bio" function (generally biodegradable or biocompatible), not usually to indicate the origin of the material. (Kabasci, 2013)

## 4. CARBON FOOTPRINT

The carbon footprint is the total amount of greenhouse gases (including carbon dioxide, So2, No2, O3 ... etc.) produced by interior users' actions. Globally, carbon dioxide emissions should be kept below 2 tons per year by 2050. Lowering individual carbon footprints from 16 tons to 2 tons does not happen overnight. It needs a huge effort for avoiding house gas emissions. (The Nature Conservancy organization, n.d.).

### 4.1 Carbon Offsetting

Carbon offsetting is a way to neutralize your emissions by funding equivalent carbon reductions elsewhere. Our daily activities at home and work consume energy and cause CO2 emissions through driving, flying, and Heating Buildings.

### 4.2 Greenhouse Gas

A green house gas is a gas that has the property of contributing to the greenhouse effect by absorbing infrared radiation (net heat energy) emitted by the Earth's surface and radiating it back to the Earth's surface. Carbon dioxide, methane and water vapor are the main greenhouse gases. Carbon dioxide (CO2) is the most important greenhouse gas. Natural sources of atmospheric CO2 include outgassing from volcanoes, combustion and decomposition of organic matter, and respiration by aerobic (oxygen-consuming) organisms. These sources are, on average, balanced by a series of physical, chemical, or biological processes called "sinks" that tend to remove CO2 from the atmosphere. (Mann, M. (n.d.).

## 5. CARBON FOOTPRINT AND HUMAN HEALTH

Many aspects of the plastic manufacturing process have not yet been studied on human health, including the carcinogenic properties of some of the chemicals involved, but many of the chemicals released are the result of myriad emissions. already known to affect and be harmful to humans. Figure 2. (Azoulay, D., et al., 2019). On the other hand, Interior design has been doing great harm. That is because of all components and materials used to complete the image. Which should be integrated for the sake of human comfort, but it leads to an increase in carbon emissions, which negatively affects his health and activity. (Author).

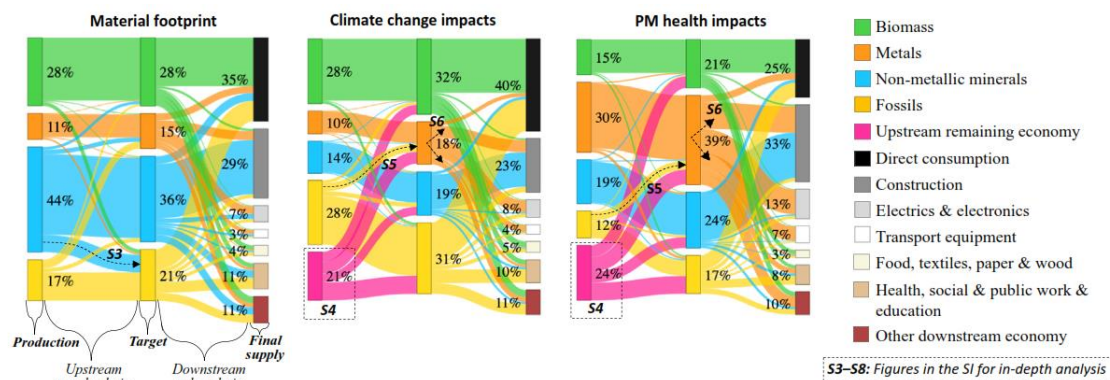
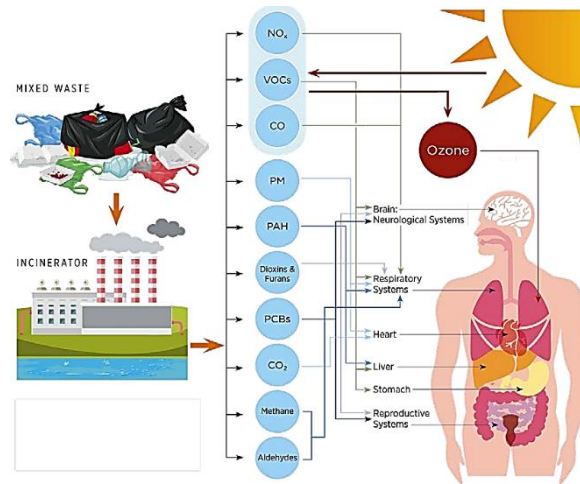


Figure 2: This chart shows addressing the direct impacts would underestimate the climate change and health impacts of global material production. (Cabernard et al., 2019)

A number of studies have pointed to the risks of greenhouse gas emissions and their impact on human health and have sought to highlight that air pollution is associated with an increased risk of

suicide in the general population and suggests that global climate change and pollution may increase risk of mental disorders (Davoudi, M. et al., 2021). Numerous studies have shown that people who are exposed to air pollutants have higher rates of depression and anxiety; in particular, high levels of NO<sub>2</sub>, O<sub>3</sub>, PM<sub>10</sub>, and PM<sub>2.5</sub> were linked to an increased risk of depressive symptoms. Other studies have suggested that air pollution may contribute to the pathophysiology of neurodevelopmental disorders while emphasizing the link between air pollution and attention/deficit hyperactivity disorder (ADHD), or linked to increased expression of neurodegenerative disease markers and have been hypothesized to play a role in the pathophysiology of diseases like Alzheimer's, for instance. (Marazziti, D. et al., 2021) Figure 3.



*Figure 3: Toxic exposure from incinerated mixed waste, containing plastic. (PINTO DA COSTA et al., 2020)*

Unexpectedly, when WRNS Studio analyzed the embodied carbon footprint of its award-winning LEED Platinum building for Sonoma Academy's Janet Durgin Guild & Commons, interior finishes came in at about 7 percent of the total. That seems like nothing can make much of a difference, as Pauline Souza - the firm's director of sustainability- mentioned ruefully. On the other side, experts might have seriously underestimated the carbon footprint of interiors, according to studies completed in the past two years. Research conducted that interior designers may be responsible for emissions at least equal to those associated with the structure and envelope of a building and interior space. (Rajagopal, A., 2021) (Penny, J., n.d.). Figure 4.

Some studies and experts are finding ways to reduce carbon pollution by testing strategies or using low-carbon alternatives. To reduce the carbon footprint of reusable indoor spaces, Bio-based materials such as bioplastics are one good substitute for that.

Improving subjective well-being as well as functioning in everyday life by enhancing individual performance and internal environmental factors is undoubtedly a major concern. Mental health as a positive state of health is a key goal for reducing our indoor carbon footprint. The fact that materials have the ability to absorb energy and release carbon and house gases is intuitive. Therefore, the evolutionary change from gray to green is important for human health and productivity. (Author).



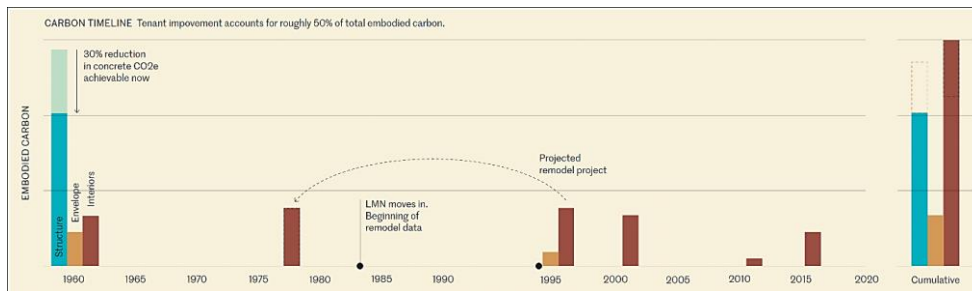


Figure 4: Chart shows the great impact of interior design on carbon emissions compared to building structure and its envelope. (Rajagopal, A., 2021)

## 6. A REVIEW OF BIOPLASTIC IN INTERIOR ARCHITECTURE

There is no doubt that plastic is one of the prevalent and widely used materials in several fields, the most famous of which is architecture and interior architecture. For example, in Europe according to a study requested by the European Parliament's Committee on Petitions, It has given this versatility, that the latest detailed report on annual global plastic production (2018) was over 359 million tonnes. In Europe, nearly 19.8% of plastic is used for building and construction, and a percentage of 16.7% for appliances, engineering, and medical purposes. (PINTO DA COST et al., 2020). Figure 5.



Figure 5: European plastic converters demand by segment in 2018, totaling 51.2 Mt, according to Plastics Europe (PINTO DA COST et al., 2020, P. 12)

Another study of “The environmental impacts of plastics and micro-plastics use, waste and pollution: EU and national measures”, The data presented in this report was collected by PlasticsEurope (the Association of Plastics Manufacturers in Europe) and EPRO (the European Association of Plastics Recycling and Recovery Organisations). The Plastics Europe Market Research and Statistics Group (PEMRG) provided information on the production and demand for plastic raw materials. Where available, official statistics from European or national authorities and waste management bodies are used for recovery and trade data. It shows that it shows that a percentage of 10% are plastics used in architecture and interior architecture as Window frames, profiles, floor and wall covering, pipes, cable insulation, garden hoses, inflatable pools, etc and 7.9% are in Building insulation, pillows, and mattresses, insulating foams or fridges, etc. (PlasticsEurope, 2020). Figure 6.

However, despite the negative impact on human health in open or closed spaces due to its emissions of toxic and carbonic gases either during manufacturing processes or disposing of it as waste, there have been attempts to manipulate the ways of using it in several ways. Technology helped in a way by mixing it with chemicals, and sometimes by reusing or recycling. Unfortunately, this did not improve the situation much, and its carbon footprint remained high in a way that threatens human health and the environment.

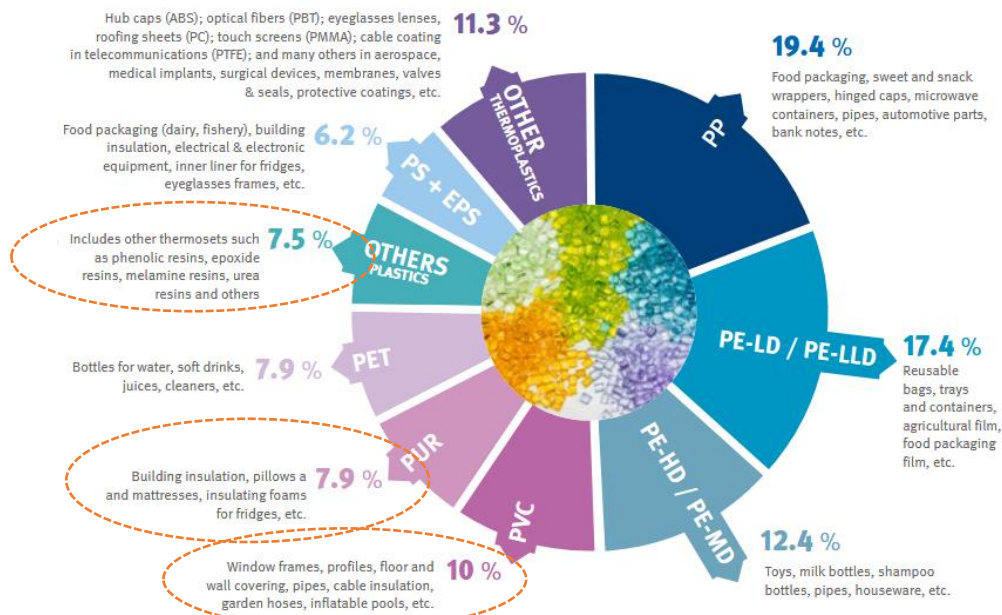


Figure 6: Plastic demand distribution by resin type 2019 (Plastics Europe, 2020, P.26)

Several studies have been conducted in recent years to study the carbon footprint of bioplastics and their effects on human health and the environment. One of them is from a group of researchers in various scientific fields. The collaboration showed that global plastic production exceeded 360 million tons in 2020 alone, a significant amount of which was inappropriately disposed of. The considerable stress and damage caused by conventional plastics endanger health. Indicates an urgent need for alternatives. One of these alternatives is bioplastic, which is defined as biodegradable bioplastics. Using bioplastics adds fewer greenhouse gases to the ecosystem, reducing the carbon footprint. In addition, because it is made from renewable and compostable plant-based biomass, it can create more functions than traditional plastics and improve environmental sustainability. The study found that the group of participants had a good understanding of the relationship between the concept of bioplastics and biodegradability, indicating a positive outlook for bioplastics. Additionally, millions of tons of conventional petroleum plastics are proven to be incinerated or end up in landfills and water bodies, destroying animals, plants, and their habitats. Conventional plastics also have a negative impact on human health by increasing levels of air pollution and food contamination. A current study found that just over half of the participants regularly or occasionally use bioplastics, primarily in food packaging, utensils, cutlery, and toys. Research results suggest that bioplastics have relatively low awareness, but this was not confirmed by the results. However, the survey, conducted in Europe, showed that

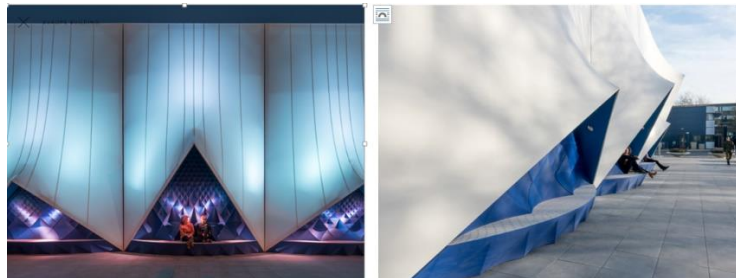
over 50% of respondents were familiar with the key properties of bioplastics. Two of his other bioplastics fundamentals questions relate to the definitions of "biobased" and "biodegradable". About 79.2% of respondents chose the most appropriate definition of bio-based products as those mainly composed of biological products and renewable local agricultural inputs. Similarly, 82.6% identified biodegradable plastics (multiple answers possible), which under the right conditions and in the presence of microorganisms will eventually degrade into their basic constituents. (Filho WL et al., 2022).

In another study in 2013, students and professors at the University of Stuttgart completed a project called ArboSkin, (Figure 7) demonstrating the potential of bioplastics in the construction industry. Thermoformable bioplastic films used are resource-efficient alternatives to petroleum-based plastics, glass or metals, and bioplastics made from partially renewable raw materials. It combines the advantages of high moldability and recyclability. (GAIA Greentech, 2022). This project aimed to develop building materials that are as sustainable as possible, yet durable. At the same time, minimizing petroleum-based ingredients and additives can support the ecosystem balance. (ITKE, 2015).



*Figure 7 : The ITKE Institute designed and built a new ArboSkin pavilion from 388 bioplastic pyramids. ( Grozdanic. L.,2013)*

Another Example was in Amsterdam. Designed by DUS Architects in 2015, the example EU building features indoor shaded outdoor seating areas made entirely of bioplastics. The bioplastic "curtains" covers the entire building with white sheets with "folds" that protect different parts of the building from the scorching sun. Dutch company DUS Architecture has 3D printed an entire life-size house using bioplastic. According to company co-founder Hedwig Heinsman, each construction project generates an average of 25% of waste, contributing to reducing carbon footprint and the negative impact on the environment. And if there is any mistake in the 3D printing, the bioplastic used can be shredded and reused. (DUS, H., (n.d.) Figure 8.



*Figure 8 : The DUS Architects designed pavilion was 300m2 facade design for mobile event conference space that remains only for 6 months. (DUS, H., (n.d.)*



The negative impact of conventional plastics on the environment is beginning to play a major role in fostering the growth of 'green architecture', which reduces the detrimental impact of construction projects on the environment. (GAIA Greentech, 2022). Bio-plastics demonstrate design flexibility in many ways, some including:

### 6.1 Diversity of Color and Transparency

Bioplastic manufacturing will be a major part of future interior design industries. But creating new materials is only the first step. Now industries must adopt these different solutions to severe environmental sustainability and eliminate air pollution.

Shellworks, a group of four designers, developed scalable manufacturing methods and processes tailored to how materials behave. They used Chitosan bioplastic to become a viable alternative to many plastic products. It has relied on natural materials, including the dyes used to color it, extracted from the peels of fruits and vegetables such as blueberries, purple cabbage, beetroot, and carrots. So, It became easy to create a sustainable and biodegradable alternative to single-use packaging, using raw materials extracted from algae. (Girard, T., 2019) Figure 9.



Figure 9 : On the right: Shellworks has made bioplastic chitosan a viable alternative of many plastics in use (Girard, T., 2019)  
 On the left: bioplastic chitosan has variable colors and translucency. (Girard, T., 2019)

### 6.2 Facades

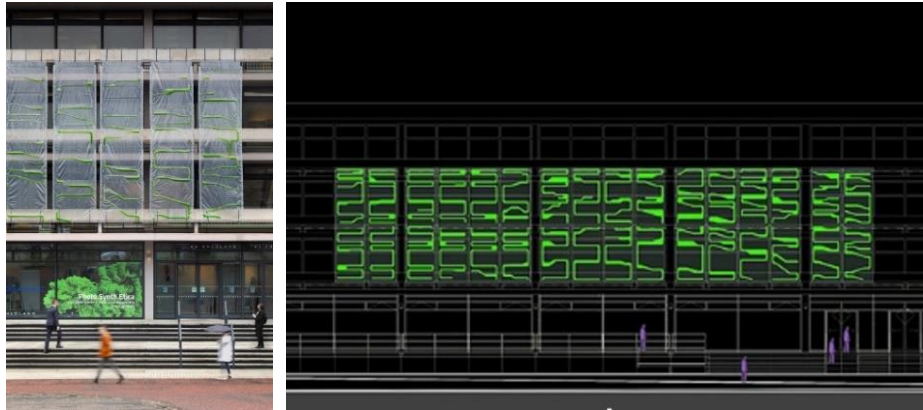
Architectural and urban planning firm EcoLogicStudio has teamed up with Climate-KIC to create a large-scale “urban curtain” called “Photo.Synth.Etica” designed to combat climate change.

Synthesis Etica is "Custom-made, digitally-engineered bioplastic vessels that use daylight to feed a live culture of microalgae and emit vibrant colors at night." included urban air introduced into the air bubbles rising through the bioplastic aqueous medium. (Walsh, N. (2018). Figure 10.



Figure 10: Photos show the facade modular bioplastics as cyberspace and relative organic molecular transactions in the biosphere... (Walsh, N. (2018).

It currently on display at the Printworks Building in Dublin Castle, Ireland, captures and stores one kilogram of CO<sub>2</sub> per day. This is equivalent to the CO<sub>2</sub> emitted by 20 large trees. The prototype consists of his 16 modules measuring 2 x 7 meters covering the first and second floors of a historic building recently featured in the Dublin Architecture Guide. Each module acts as a photobioreactor. (Walsh, N. (2018). Figure 11.



*Figure 10: The Photo.Synth.Etica is covering the two floors of the historic building located in the Dublin Architecture Guide using bioplastic installing cutting-edge technologies based on digital and biological intelligence (Gallery of ecoLogicStudio's bio-digital curtain fights climate change by filtering air and creating bioplastic - 7. (n.d.).*

### 6.3 Flooring

In a movement of turning grey to green, A Dutch company “Aectual” has shown how 3D-printed bioplastics can be used to create sustainable and customizable flooring solutions that help “build a more resilient future space. The company’s Patterns is terrazzo floors combine 3D-printed patterns with bio-based terrazzo infill, and the designer offers a wide range of patterns and designs to bring storytelling into the work. Designers are willing to consult with the client in advance and then upload digital sketches or use the company’s existing library of samples. That offers a wide range of patterns, colors, and effects making this type of flooring ideal for those who appreciate a high degree of craftsmanship in details such as floors, stairs, and even walls (McCann, C., n.d.) (3D printed architecture & interiors., n.d.). Figure 12.



*Figure 11: some photos show the variety of 3D-printed bioplastic floors of terrazzo-filled floors made from recycled marble or granite designed in a flagship-store in Dubai Mall (GAIA Greentech, 2022) (3D printed architecture & interiors. n.d.).*

## 6.4 Furniture

At MOROSO, a company of producing iconic furniture established in 1952, they focus on an artisanal approach, innovation and creative impulse in the design phase (Moroso. P., n.d), the Designer Werner Aisslinger presents the world's first natural fiber mono chair, constructed using completely new technology called Werner Islinger's "Hemp Chair". It has been produced from natural fibers such as hemp are thermoformed using a special eco-friendly adhesive developed in collaboration with BASF Acrodur into a new natural and sustainable composite material. Figure 13.

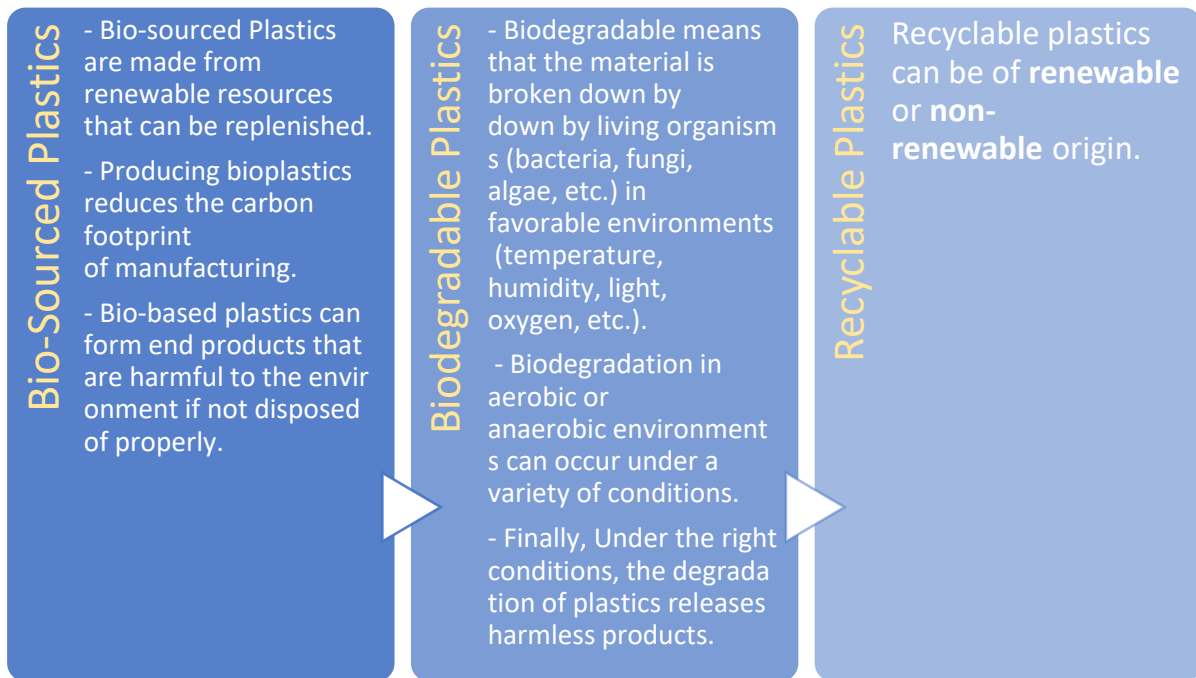
Making a complete structure out of thin layers of material is one of his most complex ways of designing and building a chair. It has been designed with soft curves and horizontal and vertical ring structures is a new approach to this complex seating typology. (Designboom, A., 2011) (Hemp chair, 2019)



*Figure 12: There are four alternative views of chairs show the difficulty when working with ecological materials is the ratio of ingredients compared to life cycle stability and component pricing. It was presented in an exhibition of prototype objects or installations. (Designboom, A., 2011) (Hemp chair, 2019)*

## 7. BIODEGRADABLE PLASTIC

As mentioned, Bioplastics are a family of materials made from renewable resources rather than fossil resources (which are non-renewable). A substance is a bioplastic if it is bio-sourced. But this doesn't make the bioplastic necessarily biodegradable (What are biodegradable plastics? , n.d.). Mixing some biodegradable plastics with other recycled plastics still reduces the performance and longevity of the final product. But not all biodegradable products are suitable for composting. The fact that current technology is limited, and even biodegradable plastics cause pollution problems and greenhouse gas emissions as the Biodegradable and biodegradable plastics take a long time to degrade in the anaerobic environment of landfills. (Wang, G., 2016). Figure 14.



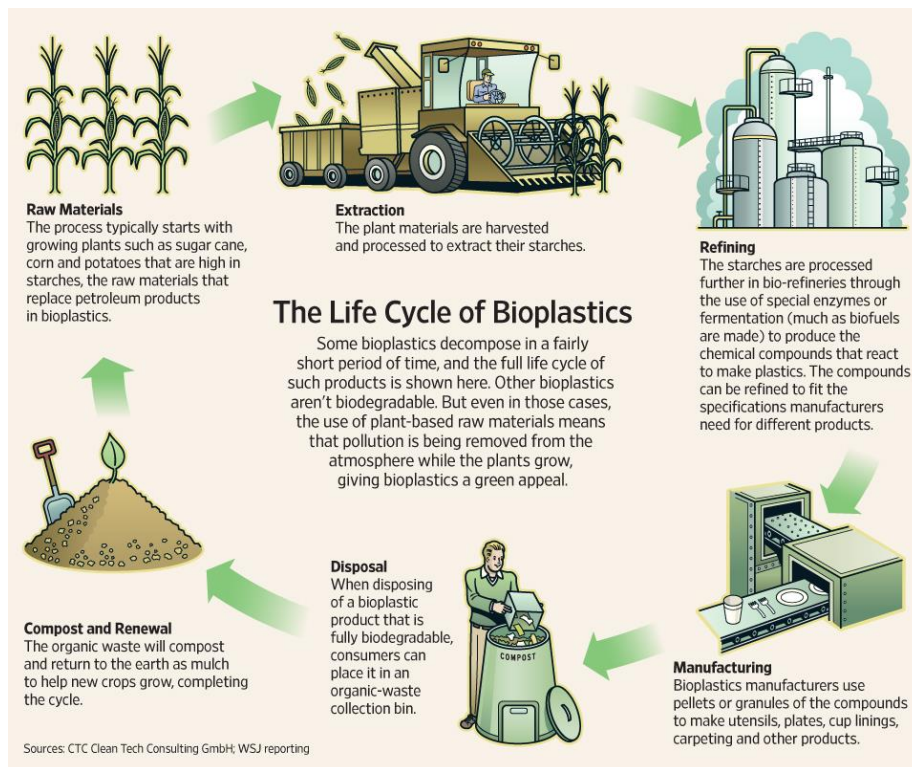
*Figure 13: The diagram shows a comparison between Bio-sourced, Biodegradable and Recycled Plastics in points (Wang, G., 2016) (Pilla, 2011) (Author).*

### 7.1 Bioplastic as a Biodegradable Material

As mentioned, biodegradable bioplastics are made from renewable resources such as plant biomass like maize, sugar cane, etc. and biodegrade under certain environmental conditions. They are relatively sustainable as they support continuous plant growth. On the other hand, non-biodegradable bioplastics also use renewable resources but are designed for long life.

As summarized in the diagram bellow, Figure 15, biosourced plastics have a cyclical life cycle in which they originate from biosourced materials and decompose to reunite. Recent exciting developments include new materials derived from starch, cellulose, and microbial fermentation processes. Starch is a renewable and commonly available resource that has become a major focus of innovative efforts. Starch is economically competitive with oil and has been used in several processes to make compostable plastics. Corn is the main source of bioplastics. The potential use of rice, barley, wheat, oat, soybean and potato starch sources in bioplastics is currently being investigated. (Solutions from technology, 2016).





*Figure 14: The life cycle of bioplastic shows its beneficial impact on environment (Solutions from technology, 2016)*

The work of making plastic from agricultural products - that are high in omega-7 fatty acids.- began more than 50 years ago. However, work continues and today the production has already received a lot of bioplastics, the main advantage of which is the cleanliness of the environment (Bioplastics - material of the future., n.d.).

### 8. ANALYTICAL VIEW OF BIOPLASTICS AND CARBON FOOTPRINT

Interior designers should recommend and specify eco-friendly and healthy materials. They should integrate sustainable practices into all of their interior design solutions. That is through sustainability principles and selection criteria covering health, reduced consumption, sustainable design components, and efficient design resource management.

Although measuring toxicity and environmental impacts inside buildings is difficult, there are ways to work with scientists to collect air samples and use computer software to simulate airflow inside buildings. Alternatively, traditional materials can be replaced with vital ones and bio-plastic is an alternative to conventional plastic as it is a contributor to several parts and elements in interior architecture design, as explained in the research.

The diagram below clarifies the benefits of taking bio-based plastic as an eco-friendly material and achieving sustainability goals. However, It helps in reducing carbon footprint in the interior atmosphere by exceeding most of the points of selection criteria for sustainable interior space. Figure 16.

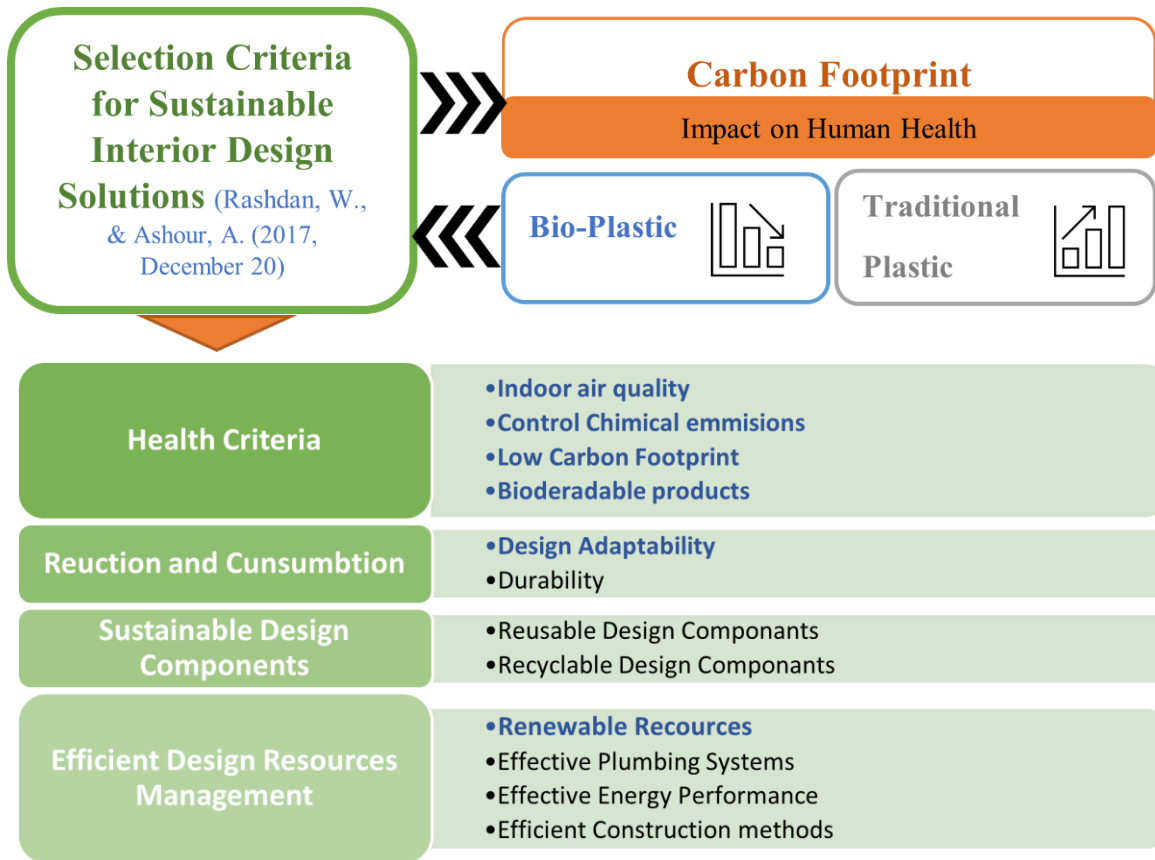
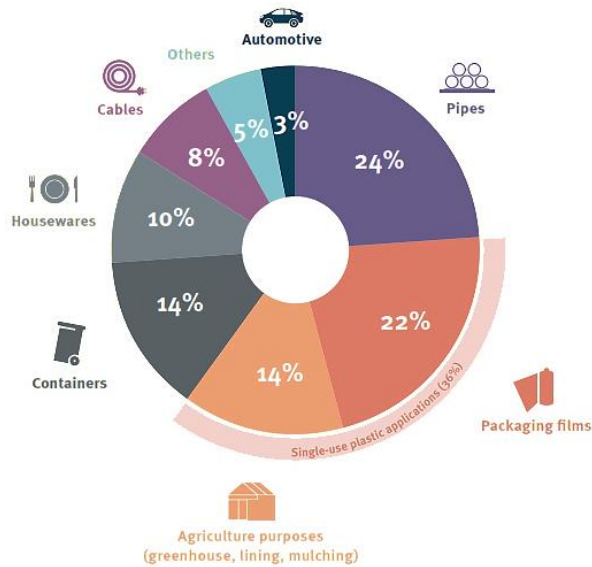


Figure16: The diagram shows how reducing the carbon footprint can meet achieving Sustainable interior criteria by selecting bioplastic material (Author).

## 9. BIOPLASTIC IN EGYPTIAN MARKET

According to a country study on the value chain of plastics in Egypt, the UNIDO project “Study on available sustainable alternative materials to plastics, and innovative packaging and recycling technologies that meet market needs in Africa to reduce plastics leakages to the environment” to Provide African stakeholders with an overview of available technology options that meet local conditions and needs, and enable them to take necessary actions to reduce the release of plastic waste into their environment. Many plastic applications are used in Egypt. Packaging film applications (plastic bags, food and cosmetic packaging, bottles) and agricultural applications (greenhouses, linings, mulching) account for 36% of Egypt's plastic consumption, which is more than one third of the total consumption, that reflects the scale of single-use plastic consumption. Figure 17. So, this study examines the production and distribution of alternative materials and single-use plastics, and plastic waste management and recycling systems. They found that a possible solution is to boost the circular economy by promoting recycling, reducing factory-level waste through resource efficiency and promoting the use of alternative materials. (United Nations Industrial Development Organization [UNIDO], Chemonics Egypt Consultants, 2021)



*Figure 15: The amount and percentage of plastic consumption by application in Egypt.  
 (UNIDO, Chemonics Egypt Consultants, 2021)*

While biodegradable plastic is made from either plants and agricultural resources or chitosan as mentioned before, the expected cost of chitosan production in Egypt is not uncommon. So, it ranges from 50 to 500 USD per industrial kilogram used for pharmaceutical purposes, which is relatively expensive and limited. Also, bearing in mind that there is no information on other bio-based materials in Egypt. (Chbib, H., Faisal, M., Fahim, I., & Everitt, N., 2019).

So, here are some points that can summarize the challenges facing Bioplastic in Egypt: (Author)

- Biological treatments for bioplastic manufacturing need a high cost.
- Lack of awareness either in Egyptian society about the importance of using biobased materials, or in the Egyptian industrial community.
- Lack of scientific research to produce bioplastic.

To face these challenges, interior designers with the collaboration with biosciences should find the best solution for each as follow: (Author)

- Select the cheaper and most suitable raw biobased material. That produced from cheaper ingredients and components like using cellulose, starch, and sugar. They are the most abundant in the Egyptian environment.
- The Ministry of the Environment in Egypt should support new product projects based on bio-based materials specially bioplastic, due to its prevalence in several fields, including interior architecture. Besides that, it should increase the awareness of using bioplastics, the great impact of bioplastic on saving our planet, and the necessity of making bioplastic an alternative biomaterial in the interior and furniture industry, especially after the state's clear orientation to green architecture and its sponsorship of the upcoming climate change conference.
- Increasing awareness of the multidisciplinary scientific research to produce bioplastics at reasonable prices for the Egyptian community, and forming research groups for manufacturing, design, and production steps.

- Increasing environmental awareness of the importance of the general orientation to work in a clean environment, starting with simple components in the design of interior architecture and its impact on human health.

## 10. RESULTS

A review of previous studies on Bioplastic and its application in interior design showed the most important points to highlight how bioplastic can be an excellent alternative material for interior space elements. It has the same qualifications and privileges as conventional plastic in an eco-friendly way and is a clean solution for interior design in both form and function.

The carbon footprint harms human health according to many research papers provided and after providing the role of interior design and its elements in increasing carbon and greenhouse gas emissions, it was clear that a high amount of Carbon footprint affects the interior space user mentally and psychologically, their behavior, and their ability to produce and interact.

Finally, this research comes to monitor the actual condition of bioplastics in Egypt. It tries to shed light on challenges facing its industry in interior architecture. Then the paper proposed some points to face the main struggling points of awareness and manufacturing of bioplastic for reducing the carbon footprint.

The paper found out that the bioplastic future in Egypt could take a long time to be a part of the main interior architecture design industry, but it would be effective and pays off in the long term. The researcher seeks to participate in upcoming research that sponsors the application of the bioplastic industry in interior architecture as part of the effective research participation to achieve the actual goal of bioplastic as one of the clean materials with a low carbon footprint, regarding the health of the occupant of the interior space.

## 11. RECOMMENDATIONS

According to the research results, the author recommends the following points:

- Enhancing the Egyptian society's awareness towards the benefits of bio-based plastic as an alternative sustainable material.
- Enhancing the Egyptian society's awareness of the importance of reducing plastic waste to reduce the carbon footprint that affects human health.
- Develop strategies to encourage designers and manufacturing companies to use bioplastics instead of traditional plastic in architecture and interior components.
- Supporting more studies related to the industry and application of bioplastics to detect which one has the lowest carbon footprint to achieve human well-being.

## 12. FUTURE STUDIES

The researcher suggests the possibility of further study in the following points:

- Bio-based plastic production types and their applications in interior design to show the suitable for Egyptian society.
- Bioplastic applications and human mental health to predict their activities and ability of production.
- Circular economy and how can it implies reducing plastic waste to a minimum in Egypt.

## 13. CONCLUSION

While a high carbon footprint affects the interior space user mentally and psychologically, it affects their behaviour and ability to produce and interact. The research aims to reduce the carbon



footprint of plastic in interior design to avoid mental disorders and psychological diseases in the future. Bio-based plastic has been added to the field to reduce carbon footprint. That to preserve the health of the space occupants, as well as the most essential features that qualify it to excel over traditional plastic as a manufacturing material for the components and requirements of interior architecture.

Regarding carbon footprint and human health, several studies have pointed to the risks of greenhouse gas emissions and their impact on human health, and have sought to highlight that air pollution is associated with an increased risk of suicide in the general population and suggest that global climate change and pollution may increase risk of mental disorders which should be integrated for the sake of human comfort, but it leads to an increase in carbon emissions, which negatively affects his health and activity.

So, the research ends with some results to meet the main goals of research follow:

- Identify bioplastic as an alternative bio-based material and its impact on carbon footprint.
- Analyzing past experiences of utilizing plastics and bioplastics in interior architecture to point out the impact on interior design and human health.
- Inducting the bio-plastic in the Egyptian environment and trying to highlight some helpful points.

Finally, the research recommends that bio-based plastic as a new concept in the Egyptian market requires a great support of many efforts and studies to increase awareness and actual application.

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