Sustainability Innovation

Biodegradable Plastic As An Alternatives For Disposable Plastic Packaging

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Summary

Throughout the project, we first focused on the research of existing environmental and health issues caused by composite plastics and the improper disposal of composite plastics. We then identified the potential solutions for such environmental problems ranging from political to educational and to technical implementation of the plan, where we eventually decided that the solution would be to introduce biodegradable plastics to the food packaging industry.

We envisioned our solution to be more than a physical implementation or government subsidy upon the promotion and adaption of biodegradable plastics. We hope to make the consumers be willing to act for sustainability instead of being forced to do so by food packaging industry or political actions.

Therefore, beside the research being done on the different types of plastics and their economic values, we introduce the educational side of our solution. The educational side is more than lecturing, where documentaries, photographs and artwork would be put on social media so influence the public in subtle ways, so that more people would willingly choose the more sustainability option in daily life comparing to a non-sustainable but convenient one.

After we envisioned out solution, we sent out a survey where we mostly touched upon the general public' s understanding over composite plastics, disposable plastics, and their attitude towards sustainability in plastic industry. It turns out that though most people do not focus on the technology side of plastics, they do have a solid understanding of the negative consequences of composite plastic and improper plastic disposal, both on the environment and human health.

For future improvements, we would put more solid research upon the chemical component and chemical structure of each kind of biodegradable plastics and predict changes in plastic disposal infrastructure to match the change from composite plastics into biodegradable plastics. More case research is also required for the potential implementation of our project.

Choose the Topic

Identify the Challenges

1. Economic challenge

Due to the affordability of plastic packaging, almost all food delivery service involves plastic usage, ranging from milk tea bottles, plastic straws, all the way to plastic food case and plastic bags. Though plastics are affordable and have low transportation costs due to its lightweight, it costs more in the long run as it burdens the environment, for the air pollution generated during the process of plastic production, and management costs due to improper disposal.

Economic loss in plastic waste management can be both direct and indirect. Direct economic loss includes clean-up costs associated with soil contamination, water contamination, health care costs, and potential losses in the economic value of certain land or area. Indirect economic costs involve the impact of waste upon biodiversity, ecosystem, and general residential health.

China is one of the head producers of plastics around glove due to its strong production economy, but the recycling rate of waste plastic is quite low, partially due to that recycle proves not to be economically efficient. In 2019, about 63 million tons of waste plastics need to be disposed of in China, of which 18.9 million tons of waste plastics are recycled and reused, accounting for only 30%. Most waste plastic recycling enterprises have been in small-scale and adopted disorder production and operation.

Meanwhile, plastic production involves the carcinogens such as benzene, vinyl hydrochloride, along phthalates- flexibility materials added into plastic production which cause endocrine disruption in humans and other organisms. Those pollutants are released when the plastic is disposed of improperly, leading to soil contamination and bioaccumulation, which contributes to indirect costs by damaging natural resources and ecological habitats.

2. Mental Challenge

The packaging of food delivery is significantly affected by the mental process of both the consumers and the sellers. Both consumers and sellers would prefer a relatively over-packaged food delivery, instead of a more efficiently packaged food. Not only does an over-packaged food delivery looks less likely to spill, but it also

contributes to the branding of the food store, leading to possible increased demand over the seller’s food.

Since almost all of the sellers’ profit is directly related to the demand of the customers, they provide service. The ability of the products to retain and attract customers or possibly to act as stunts to raise the price is becoming crucial to sellers to survive and cater to the demand of the market. Switching to new alternatives, such as more efficient packaging, involves numerous aspects concerning the seller’s reputation.

As the customer for food delivery does not have the opportunity to experience the restaurant and have a more thorough perception of the food it is likely to offer, the packaging of the food became crucial. The packaging not only serves as a branding purpose but also shows efforts that the seller has put into the package to ensure the food stays as intact as possible, despite whether the packaging is efficient.

For instance, when using online ordering services, customers don’t have much information to determine the quality of the dishes. Therefore, the ratings and feedbacks from other customers are the only references for the new customers to have a basic knowledge of the quality of the restaurant. The rating involves comments on the integrity of the packaging, which bothers the sellers when delivering the products. One of the most common negative comments given by the customers is the missing or the spilling of dishes[1]. Although the delivery companies are partially responsible for the loss, sellers strive to avoid the possible negative impact on their reputation by improving the packaging, either by improving the form of packaging or by using more sturdy material, leading to the problem of over packaging.

In addition, the attractiveness of the packaging is becoming an increasingly emphasized part of the products sold to the public since some of the customers are ritualistic before enjoying the food, where they post their dishes onto social media. Research revealed food-related posts have been the top 100 topics on major social media like Instagram[2]. Sellers sought to advertise utilizing such psychology, by making the packaging more delicate or more “extravagant”, which enhances the branding of the food delivery shop.

3. Environmental challenges

The current environmental challenges are classified as threats posed by plastic usage, especially mismanagement of plastic waste.

Mismanagement of plastic waste is defined as having disposal processes that

release toxic materials, such as improperly constructed landfills, un-collected plastic waste, or dumping waste into natural places without treatment (such as disposing plastics into Ocean).

The plastic waste mismanagements cause impacts including agricultural impacts, ecological impact, environmental challenges over residents, public health issues, as well as industrial pollution, domestically and globally.

When plastics are disposed into landfills, the toxic leaks into the soil, causing soil contamination; water filtration through the contaminated soil also leads to contamination of ground water supplies, leading to potential threats over public health. As most un-recyclable plastics, which are the major plastics in landfill, contains toxic such as Benzene and other endocrine disruptors, it poses health harm upon the residents using the water source as well as species (especially amphibians) in the ecological habitat.

In aspect of ecology and public health, improperly disposed plastics would degrade into micro plastics, be ingested by micro-organisms such as phytoplankton, and leads to bioaccumulation of microplastics along with the toxic chemicals (including inflammables and added chemical to max plastic flexible). Such bioaccumulation process would lead to biomagnification as the trophic level increase, resulting in chemical toxic build up in human body.

4. Physical challenge

To address the prevalence of plastic packaging, a better alternative is most likely required. The sustainability alternative should satisfy the current benefits brought by plastics while providing more benefits, either economic or physical, to promote delivery companies and sellers to adopt the sustainability alternative.

Plastic packaging is prevalent due to its low price, and its flexibility with almost all kinds of meals ranging from drinks to solid food. Plastics are portable, light, and do not require various new designs for different food packages.

Plastics perform well in contamination prevention and easiness in handling (including leakproof and weight enduement), making it the most desirable package material.

However, the current plastics used in the food packaging industry are barely recyclable and stays as micro-plastics even though it degrades. The challenge is the develop efficient packaging out of other materials such as paper bags, paper food boxes, or new material alternatives.

5. Political challenges

Political management is a huge part of environmental management. Political power can exert pressure upon industries to develop new sustainability models, regulate waste disposals and material usage for better resident life, but it can also lead to environmental damage when such power is not exerted.

The goal of this section is to give examples of challenges- current inefficient political managements that hinder the development of a long-term sustainability goal.

1. China has no standard restrictions on the types of degradable plastics, which provi
des opportunities for the company to take advantage of the loopholes of policies by producing non compliant degradable plastics.

2. Due to policy support, many informal companies produce degradable plastics, but the property and specifications of their products are doubtful (according to the field investigation, many degradable plastics stews from milk tea shops do not indicate production standards and company information which is lawbreaking)

3. Since the degradable plastics currently on the market are mostly compostable, their degradation process requires high temperature, high humidity, and the effects of microorganisms which degrade significantly slowly in the natural environment, so it needs to be treated separately from other garbage. However, the country does not have a clear policy on how to effectively classify and recycle degradable plastics, which has led to the fact that degradable plastics did not put degradation into practical effect.

4. The use of degradable plastics, from production, popularization, utilization, processing, and recycling, involves the operation of the entire society. The government is still not mature enough to provide a full industrial chain in the current stage. As far as the international situation is concerned, the United States and the European Union are also in an incomplete stage. As for the formation of the entire industrial chain, more practice and time are needed.

Challenges with citation references

Identify a Root Cause

The root cause is defined as the reason the current situation of plastic usage generally satisfies the needs of the market. The root cause is described in three aspects, including economic aspect, physical, and political management.

1. Economic
The current economic root cause is the economic availability of plastics in comparison to other packaging materials, and the relatively higher costs when it comes to recycling plastics.

Plastics are used in almost every food delivery seen in Shenzhen, due to their availability in the market and their low purchase cost. Although big food delivery firms such as Starbucks and Heytea would be involved in new material usage and the recycling of bottles, including the adoption of paper straws and PLA plastics, most food delivery business does not have the economic ability and the branding demand to conduct such a change. Therefore, to achieve more sustainable development in the food packaging industry, the work mostly lies upon the development of a better recycling strategy and new materials that would cost less while not being unsustainable as plastics are.

The internal costs of recycling plastics are much higher than the costs of manufacturing plastics. The manufacturing costs of plastics are very low, with the national average price of PET beverage bottles and jars Polypropylene at 10.47 cents, the average price for natural high-density polyethylene at 70.25 cents, and the price of polypropylene at 28.34 cents per pound. On the other hand, for recycled plastics, the price is much higher comparing to its manufactured counterpart. Currently, state-certified recycling centers pay a minimum of $1.65 CRV for aluminum cans, $1.31 CRV for clear PET plastic bottles, and$0.58 CRV for HDPE plastic bottles.
Utilizing new plastics would generate higher profit compared to recycling and use recycled plastic materials.

Besides, due to the various kinds of plastics utilized in the food packaging industry, it is hard to waste treatment centers to discern the recyclable plastics from the non-recyclable materials, as plastics are produced from different firms, making them not uniform in terms of their ability to be recycled, making the recycling process costly and inefficient. To address such problems, political regulation over plastic producing

firms and food sellers is required.

2. Physical

The Physical aspect of the root cause is defined as the physical properties of plastics that make it both the most prevalent packaging material and the most unsustainable option in the food delivery industry.

The low thermal conductivity is one of the roots causes why the world is awash with plastics. As the first thing that sellers need to consider is customer satisfaction, they have to make sure that the containers are not too hot to hold but the food inside is warm. As a result, thermal conductivity becomes an essential factor influencing how they choosing materials. Consequently, plastic materials are popularized. Comparing with metal, for amorphous plastics at 0-200°C, the thermal conductivity lies between 0.125-0.2 Wm-1K-1, which is around 1/1500 of that of most metals.

Plastics are low dense, but have a high specific strength, contributing to plastic' s low transportation costs and its resistance to shape deform, making it the desired material for the food delivery industry. From the website Omnexus, the data illustrates that, typically, plastics have a density from 0.7 to 1.5 g/mc3, which is approximately one-fourth of that of steel and half of that of aluminum (about 2.71 g/mc3) Despite having a much lower density comparing to steel and aluminum, the strength of plastic material is close to the strength of steel, preventing the food from being damaged during the transportation process.

While being a desirable material in the food delivery industry, plastic material contains various chemicals that would contribute to adverse health effects in humans when disposed of improperly and contributes to the issue of global warming by releasing significant greenhouse gases. Such an aspect is further explained in the political management section.

3. Political management

The political management root cause is identified as the waste treatment for disposed plastics, which ultimately has led to the pollution of the environment and adverse health effects. The current management system has two problems, one being the proper disposal of plastics waste, the other being the waste treatment system.

The article Public and Environmental Health Effects of Plastic Wastes Disposal: A Review pointed out: "Since 1950 to 2018, about 6.3 billion tonnes of plastics have been produced worldwide, 9% and 12% of which have been recycled and

incinerated, respectively." The rest of the plastics has been improperly disposed of, including exposure to air, high temperature, and the disposal of plastic waste into the ocean, all of which leads to the release of toxic material (such as phthalates, flame retardants, heavy metals, etc.) the article also mentioned that an approximate 8 million tons of plastics are released into Ocean each year, leading to the formation of microplastics in sea organisms, which eventually accumulates in the human body as human ingests seafood.

The lack of political management of plastic disposal has been a crucial root cause of the improper disposal of plastics. With the loose political management, it costs less for waste management and the government to allow plastics to be improperly disposed of (especially be disposed of in Ocean) in natural environments. Improper plastic disposal is not only harmful to the domestic environment but also to the global environment.

The other issue lies in the ineffective plastic treatment process.

In the treatment of urban plastic solid waste, three methods are currently mainly used: landfill, incineration, and recycling. In the January-March period of 2021, China's plastic production was 17.83 million tons, and 80% of the plastic was landfilled to dispose of.

In most landfills, plastics can be decomposed, but it takes an extremely long time ranging from 20 to 1,000 years. Because the wasted plastic in the landfill is densely packed, it causes a lack of oxygen which makes it biological organisms difficult to decompose into biodegradable materials. Besides, when the garbage is decomposed, a significant amount of methane is being released, contributing to global warming. At present, the mainstream holds that the relatively most environmentally friendly way to dispose of disposable plastics is granulation, which requires plastic to be crushed into small particles, mixed with new plastics to reproduce recycled products. However, without strict government regulation upon such process, the plastic materials produced from recycling would be unsafe to be used in health products and food packaging, thus not resolving the problem of ongoing plastic production.

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Generate Solutions

i. Government’ s regulation and promotion of Standard packaging in food delivery services

Plastics are economically affordable and convenient but pollutes the environment due to the various problems associated with plastic disposal processes and waste management regulation. Cardboard and paper package, on the other hand, though is less economically affordable, have a shorter degrade and decomposing period, making it a more environmentally friendly material comparing to plastics. With government’ s regulation upon the usage of plastic and the promotion of a standard packaging material such as cardboard, less burden is aid upon the environment and the extra government must perform to solve the issue of improper plastic management and disposal. The plan does have drawn back, being the unwillingness of sellers to switch to a more economically costly packaging; economic incentives might be needed for such a change. The plan should be executed through a period more than ten years, giving the food delivery market and plastic production companies the enough time to adjust to the new model of food packaging.

Such plan, in the long run, would substantially decrease the external costs associated with environmental pollution, and the altered market is likely to adjust to the model with efficient political and economic management.

ii. Standardize materials that is most environmentally efficient

Governments and responsible organizations have been searching for alternatives of the prevalent plastic materials, and to categorize the materials found, multiple approaches could be adopted. Common guidelines sort the material by their cost to manufacture, feasibility to be applied in commercial means, or by their environmental efficiency. With the goal of sustainability in mind, the prior expectation of the material should be that it possesses relatively high efficiency.

The term environmental efficiency is defined by the ease to compost, reuse or recycle the material with least adverse influence on the environment.

Prospective materials in place of plastic includes tree pulp paper, PLA, bamboo pulp paper, metal, edible material etc.

Tree pulp paper and bamboo pulp paper:
These two materials were compared side by side for their similarity in application. Regarding packaging industry, paper is one of the most quantitatively produced material. Compared to conventional tree pulp paper, bamboo pulp paper contained no bleach, and its fiber is more easily degraded under natural process. Moreover, the amount of water to irrigate bamboo is less than that needed to water a tree. Therefore, the environmental efficiency of the bamboo paper outshines that of tree.

Metal material :
These are the alternative to the cutleries in food packaging. Each material is exceptional at its environmental efficiency, where metal like stainless steel can be reused easily with appropriate sterilization. However, the pollution when producing steel is non negligible. In comparison, the edible cutlery contains wheat, sugar etc., there is almost no issue with recycling and reusing since the utensil is directly consumed, and the edible cutlery is completely compostable due to its constituents.

Tin foils are also used in food packaging but the environmental cost to produce and recycle tin is much greater than organic substances.

iii. Promote government subsidize upon invention of biodegradable plastic

Degradable plastics refer to a class of plastics whose products have various properties that can meet the requirements of use, remaining unchanged during the storage period, and can be degraded into environmentally substances under natural conditions after use. At present, it' s essential for China to combine with the implement of the law of plastic bag restriction, to subsidize the degradable plastic as the replacement of the previous plastics that was hard to be recycled, and also confirm about the standard on the types of degradable plastics and prevent a variety of companies from producing unsatisfactory products.

iv. Promote government subsidize upon the price of packaging/biodegradable plastics

After compared with different kinds of plastics, the PLA, polylactic acid, are the most suitable alternatives for current plastics in the market.

The cost of producing PLA is relatively low. The manufacturing process in most factories of polylactic acid usually used lactic acid as raw material, and the lactic acid mostly are produced through the fermentation of starch. At present, the United

States, France and other countries have developed a new line of production that consume agricultural agricultural and sideline products as raw materials to produce lactic acid, then producing polylactic acid. The most common method is the most popular on the ground that the number of the step required is the least. Under the condition of participating of dehydrating agent, the hydroxyl and carboxyl groups in lactic acid molecules are dehydrated by heat and condensed, then directly synthesizing oligomers. After adding catalysts and rising the temperature, the low molecular weight polylactic acid will be polymerized into the higher molecular weight polylactic acid, which is the finished product. And the raw materials can be obtained from grounding up the shell crops, such as corn, and then extracting starch needed from it. After some simple processing, the starch is made into unrefined glucose and those glucose is fermented in a manner that is similar to the method of using it to produce beer or alcohol, and the glucose becomes lactic acid which can be used to produce PLA. As the shell crops is cheap and catalysts can be recycled, the cost of producing PLA by this process is very cheap.

In conclusion, from the economic and chemical engineering side, PLA is a perfect contender of the mainstream plastic materials.

v. Promote eat in restaurant instead of using food delivery

Since from 2011, food delivery market has developed in a rapid way. The scale of the online food delivery market reached 291.25 billion yuan in 2019 and reached 346 billion yuan in 2020. Due to the 2020 epidemic, the convenience and diversified consumption options of online shopping have attracted more and more consumers. In order to attract more customers, offline restaurant should focus on maintaining regular customers by the way of improving in-house services and environment. Therefore, as the consumer can have the full-service in the offline restaurant and won’ t be distracted by the noisy environment with the same price as the online food delivery, so the customers will be more willing to have the meal in restaurant. Meanwhile, the restaurant could exploit Wechat programs that could allow the consumers to queue up online and message them about the real-time situation. As a result, customers could go to the restaurant without any waste of time and this is as convenient as the online food delivery.

vi. Promotion of biodegradable plastics; types of degradable plastics

Complying with the global environmental protection trend and the clear regulations of the plastic restriction order, biodegradable plastics are a good choice in today's market.

Degradable plastics refer to plastics that retain the original properties of plastics, and can be degraded into substances that are not harmful to the environment after use under natural environmental conditions or under specific circumstances. The degradable plastics currently on the market can be divided into two types, oxo-biodegradable and hydro-biodegradable. oxo-biodegradable plastic undergoes chemical degradation by oxidation and converted to carbon dioxide, water and biomass. hydro-biodegradable undergoes physical degradation by hydrolysis - plastics and a drastic reduction in molecular weights- and get the same result. The following are some specific types of biodegradable plastic that are suggested to use.

PBAT is stand for polybutylene adipate terephthalate which belongs to Thermoplastic degradable plastic. PBAT is fully derived from fossil-fuel and contains not only good ductility and elongation, but also good heat resistance. PBAT is often used in bag and works to speed up the rate of composability to comply with compost regulations. Due to its good flexibility and fast biodegradability, it is usually used to combine with other plastic to increase their quality in the product. PBAT don’ t produce any harmful toxic residue in degradation and it is one of the best degradable materials in market applications at present.

PLA known as poly-lactic acid is a thermoplastic polyester. PLA is largely used in 3D printing and it is also a degradation plastic. PLA can be produced to make cups, lids, cutlery, straws and containers. PLA is made from Biodegradable materials extracted from biomass resources such as plant fiber, starchy plants like corn. Starch from corn kernels is processed into a bio-polymer that looks, acts, and performs like petroleum-based plastics such as PBAT which just mentioned. However, the advantages and disadvantages are relative. Though PLA degrades really fast, its application is limited to short-term plastic products. Because it is very sensitive to temperature and humidity during processing, if company can control it well, then can get products with a specific crystalline. At the same time, its processing is very difficult, and the requirements for equipment are in very high quality. Most of the company can’ t afford the production equipment. Though PLA is one of the most environmentally friendly plastic at present, the cost of production still needs to be improved in the future development.

To sum up, PLA is more environmentally efficient for containers and the edible substance is more suitable for utensils and cutleries, both materials come with a low environmental impact after the first usage.
PHA is biodegradable, bio-compatible plastics comprising of polyesters of R-hydroxy alkanoic acids. The biggest difference between PLA and PHA is PLA is produced by sugar in a two-step polymerization process through bacterial fermentation. But PHA biodegradable plastic is made by bacteria in the polymerization process. PHA can be completely degraded into β-hydroxybutyric

acid, carbon dioxide and water in the organism.

PHA plastic has good bio-compatibility, but the producing temperature range is limited, the thermal stability is weak, contains high brittleness, the production quality is unstable, so it cannot be widely used in sustainable used product. Suitable for disposable medical supplies or instruments, such as surgical attire, medical stitches, bandages, stents, etc.

vii.Government Investment on invention of recyclable plastic used for food package
According to Laura Degallaix, who is FDE director of environmental sustainability, "To play our full part in the circular economy, food and drink manufactures need access to a secure supply of safe and affordable recycle packaging materials for our products." Currently, recyclable packaging infrastructure extremely lack investment. In order to create a kind of true circular economic of plastic, it is essential for the government to innovate and develop the recyclable materials that are commonly used in food and drink manufactures. Through the way of offering enough financial funds, with safe and affordable recyclable plastic being invented, the government could gain much more revenue than its previous investment spending, since the plastic packing recycle will play a part in create the circular, and therefore contributes to the sustainability development, which will also be the key to achieve a balance point between the economics development and environmental protection.

viii. Education of general public on the topic of plastic, encourage consumers to bring their own cup when buying drinks

Another probable solution is to encourage consumers to use their own containers or cutleries. For instance, the consumers can bring their own cups for beverages. In order to achieve this goal, governments and responsible firms can respond to the new solution; governments can introduce new policies to recommend people to bring containers for beverages, or to firms, they can offer discounts as incentive for consumers that uses their own cups.

However, this approach is not as applicable when we consider the actual benefit of the sellers. One of the most important features for sellers to distinguish their products is by their packaging, without packaging, consumers lost most of their ritualism of consuming the product, where they flaunt their delicately packaged food on social media etc. Therefore, the competition between firms intensifies and firms make less profit than they used to.

Type of Biodegradable plastic
Solution references

Identify the Criteria

1. Efficiency
Efficiency is defined as the rate and application extent at which the solution could be implemented. The rate at which the solution is implemented takes factors such as worker educational period, physical construction period, political implement period into account. A solution that is applicable to a wide range of circumstances and is quick to implement will be given a higher number.

2. Economic cost
Economic cost is defined as the economic investment it takes initially to implement the solution, and the affordability of the final product from the solution (if there is any), disregarding the potential long term economic benefit. A solution that takes less initial investment and is priced lower is ranked higher on the scale.

3. Political resource
Political resource is defined as the number of political agents and organizations that is involved and required in implementing the solution. A solution that involves relatively few political agents and organizations is ranked higher on the scale comparing to a solution that involves relatively more political agents and organizations.

4. Public acceptance
Public acceptance is defined as the extent to which the new solution challenges the original structure of business, public infrastructure, or political management over achievement of sustainability goal. A solution that does not challenges the original structure is ranked higher on the scale comparing to a solution that challenges the original structure.

5. Safety
Safety is defined as the probability on the amount of harm the new plan might implement upon citizens and environment both in the short run and long run. A solution that has less probability in harming the public and environment is ranked higher on the scale comparing to a solution that poses more potential in harming the public and the environment.

Evaluate the Solutions

Criteria:
1. Efficiency
2. Economic cost
3. Political resource
4. Public acceptance
5. Safety

Each criterion has a maximum of 8 points, adding up to 40 points in total.

I. Government’ s regulation and promotion of Standard packaging in food delivery services 4+7+5+5+7=28

II. Standardize materials that is most environmentally efficient 5+6+7+8=32

III. Promote government subsidize upon invention of biodegradable plastic 7+5+5+7+5=29

IV. Promote government subsidize upon the price of packaging/biodegradable plastics 7+5+5+7+8=32

V. Promote eat in restaurant instead of using food delivery 8+7+6+3+3+8=32

VI. Promotion of biodegradable plastics to the market and food industry; types of degradable plastics 8+7+6+6+7=34

VII. Government Investment on invention of recyclable plastic used for food package 6+5+5+8+7=31

VIII. Education of public on the topic of plastic, encourage consumers to bring their own cup when buying drinks 6+8+7+8+8=37

Evaluation chart
Type of Biodegradable plastic

Make an Action Plan

Intro
1.1. Final solution description

With the rating chart, the two highest solutions are solution viii. Promotion of biodegradable plastics to the market and food industry, Education over and solution vi. Education of public on the topic of plastic. To achieve a more effective result, we decided to combine solution viii and vi.

The education component of the final solution would provide public, including product designers, established and future food companies, established and future food delivery companies on the need to utilize bio-degradable plastics. To increase the demand of biodegradable plastics, consumers are informed through the education over sustainability and ecosystem to convince consumers in reducing the number of plastics used and choose biodegradable plastics over composite plastics.

With the education component included in the final solution, it is expected that the promotion of biodegradable plastics into the food packaging realm with me more effective. However, with the current high price of biodegradable plastics, one more component is included, that being government subsidy over the biodegradable plastic industry in early stage of changing the majority of composite plastic food package into biodegradable plastic packages. With the government subsidy and education over public, the promotion of biodegradable plastics would be more successful in the food package industry.

To sum up, for the promotion of biodegradable plastics to be successful, it is crucial to consider educational factors and economic subsidy from the government to make the plan more efficient and grounded.

Solution design
The solution design component is broken down into various parts, including scope, aesthetics, experience, emotional appeal, technology, future growth, Expected Results in a broader context, and implication for future industries.

2.1 Scope
The scope of the solution is described as the actions that influence the public verses

the actions that influence the public as individuals. A large scope, for instance, would be a social media talk on platform with significant number of viewers. A small scope, in contrast, would be personalized appeal towards an individual to make certain choices, in this case, to reduce the usage of plastics or choosing biodegradable plastics over composite plastics.

When it comes to the promotion of biodegradable plastics, the ideal media would be social media, in forms of comic, photography, and online articles, which all exists on the larger scope, as it is less individually designed.

The education aspect of the solution also exists on a large scope, as it mostly uses well established scientific information and general facts to convince the public to make more sustainability choices. Such sustainability choices include the reduce in plastic usage, which can simply be done by bringing one’ s own bag to shop and bring one’ s own cup when buying drinks.

The economic aspect of the solution has the potential to influence the consumer on an individual level. Food delivery owners strives for the low costs when using food packaging. With the proper increase in taxes upon composite plastics and subsidize upon the bio-degradable plastics, producers are more willing to choose bio-degradable plastics. Consumers, when facing the policy of “bring a cup for 5 yuan decrease”, is also appealed towards their sense of emotion, which is an individual scale.

The solution combines larger scope (that focuses on knowledge and appealing to logic) and smaller individual scope (focusing on appealing to the individual’ s emotion) to achieve an effective result in sustainability development in food packaging industry.

2.2 Aesthetics

The aesthetic aspect of the solution mostly lies in the design of educational media.

The education aspect of the solution includes collaboration with local conservation agencies such as the OCT wetland conservation, online articles, and in the realm of art. The collaboration with local agencies does not require much aesthetics to be put in place, while online articles and art would require web design skills and artistic skills combined with the understanding over the topic.

Aesthetics is crucial in the educational aspect upon sustainability. Documentaries, media cartoon, and photography are great tools to gain the public eye upon sustainability crisis existing in the environment such as microplastics. Turning sustainability from a “cliché” topic into a more engaging topic with aesthetic elements increases the rate of participation of consumers over the support of

biodegradable plastic products.

Aesthetic elements attract the public’ s attention in it beauty, and it increases public awareness without explicitly telling the public to take certain actions according to scientific research.

2.3 Expected public experience

After raising public environmental and sustainability awareness with off-line meetings, collaboration with local conservation program, and aesthetics, an increase in willingness to participate in sustainability actions from the public is expected. With the raise in awareness, it is easier for both producers and consumers to shift towards a more sustainable approach, even though the introduction of biodegradable plastic to replace conventional plastic material challenges the conventional food packaging model. Therefore, consumer’ s experience with the eventual substitute of biodegradable plastic for composite plastic is expected to increase in satisfaction comparing to a model where no economic incentive (largely coming from government subsidy) and no education is introduced.

2.4 Technology

To increase the economic efficiency of biodegradable plastic, it is reasonable for government to invest in new technology in biodegradable plastic production that would decrease the market price without having the government to subsidize the market price of biodegradable plastics.

In consideration over the costs required to clean and restore environment contaminated by composite plastic production, such investment is worth it, as a more sustainable model decreases the need and amount of implicit costs, therefore resulting in positive economic results in long-run.

2.5 Growth

Growth is defined as the rise in popularity of a certain approach or product, and the increased demand for the final product.

When it comes to promotion of biodegradable plastics into food packaging industry, biodegradable plastics is expected to rise in demand together with education and government subsidy, while a more sustainable development model and less plastic pollution will result in the environment.

A positive result, in this context a increased public awareness over sustainability ideas and a environment with less pollution, would create a positive feedback look where other sustainability approaches is likely to gain more support and put into action. In other words, the solution would not only result in increased demand in

bio-degradable plastics, but also potentially contribute to future goals and plans in sustainability action with both the increase in public awareness and a convincing sustainability development model.

2.6 Expected Results in a broader context

The introduction and the eventual replace of biodegradable plastic for composite plastics in food packaging industry would decrease implicit costs required in cleaning shoreline and ocean waste of which a large component is plastic and is costly due to the large amount of labor it requires. But beside from considering the issue from an economic aspect, it is important to acknowledge the amount of damage plastic waste has on developing countries, both in the environmental aspect and public health realm. By using biodegradable plastics, the requirement of labor-intensive work in plastic treatment would decrease, and thus contributing to a better health condition, especially in developing countries.

2.7 implication for future industries

The solution’ s implication for future industries is that such model acts as a spark for the evolution of industrial design to put more consideration on the factor “sustainability” when inventing new materials, as well as how the new material could be introduced to the public in various scope sizes, in need of economic incentive, as well as the new material’ s specific target for a better consumer experience, environment, and even public health.

Solution test

The solution is consisting of three aspects. A major part of the solution is the introduction of various types of biodegradable plastics into different component of plastic package based upon the function and disposal of each type of biodegradable plastics. (further specified in prototype) The auxiliary parts of the solution are public education on sustainability and government’ s subsidy upon the price of biodegradable plastics before the demand for biodegradable plastics in the food package industry stabilizes.

3.1 Biodegradable plastic aspect implementation
The solution of changing from composite plastics into biodegradable plastics is going to be first proposed to big and branded food companies, an example being Starbucks and heytea.

3.1.1 Bigger and branded food companies have more available economic resources,

thus being more viable at investing in plans that would benefit then company in the long run but requires investment in the short term.

3.1.2 Bigger and Branded food companies have larger influence on the food package industry and consumers attitude towards biodegradable plastics. The initiation of the adoption of biodegradable plastics in such branded companies would convince the consumer to adopt towards the biodegradable plastics due to the credit that consumer gives to bigger, branded, and more visited food companies. Smaller companies and the competitor of the branded food companies would also be influenced upon the idea of biodegradable plastics.

3.1.3 The influence over both the market and consumers would start from existing credible firms. The manufacture that provides large, branded food companies would develop a line of biodegradable plastic production, and the development of such manufacture line sets stage for the selling of such manufacture biodegradable plastic into the market and how other food companies is easier to adopt them.

Already existing example includes the adoption of paper and PLA straws from composite plastic straws. Companies such as Starbucks and HEYTEA took lead in the adoption of paper and PLA straws. With the large and solid consumer base both companies have, the two companies help spread the idea of paper and PLA straws without losing consumers due to non acceptance of such adoption of new type of straws.

3.2 Educational perspective

3.2.1 The educational perspective is going to take place in two spheres. One sphere being digital focus, and its main gain goal is to use art forms, photography, documentaries, and scientific news articles to convince consumers to accept the idea of biodegradable plastics be used in food package industry, and how that might raise the price of the total consumption. Such act through social media not only make consumers used to the idea of biodegradable plastics and sustainability practice at price of an increase economic costs over product purchasing, but also helps the consumers to adopt to the new model being proposed by the branded food companies.

Such forms include short scientific videos to be post on titoki, articles on WeChat official accounts with a large and solid fanbase, as well as documentaries to be made and posted on video platforms such as bilibili. The documentary is expected to be short and engaging, as long documentaries and strenuous to make and harder to keep its audience till the end.

3.2.2 The other aspect of the educational perspective solution would take place in

public sphere, focusing on having education over sustainability practices and environmental science in general. Specific product focused lectures should be avoided to clean the suspect of advertisement over specific products, which would backfire the whole solution plan.

Lectures are expected to be held in schools and conservation organizations (such as OCT wetland conservation) to educate students upon basic sustainability practices, the harm of composite plastics, and the science behind biodegradable plastics. Such lectures would educate the students on a deeper level, which would also benefit other sustainability practices to be implemented in the city in long run.

Such lectures would also be live streamed online to increase its influence over public upon sustainability practices.

3.3 Government subsidy perspective

Government subsidy wouldn’ t play a role until Biodegradable plastics has been a viable plan to take over most composite plastic packaging. That would first require the manufacture of biodegradable plastic to be matured and be more than a single supply line for a specific company. The specific companies would first adopt to biodegradable plastics, and as more and more company adjust is where manufacture could negotiate with government to subsidize biodegradable plastics to establish the market for biodegradable plastics.

The requirement of subsidy from the government would involve the hand in of specific data from the start of biodegradable plastic adoption in specific branded food companies, as well as the proposal of a more efficient plastic management model together with the predicted economic benefit cost in the long run. Environmental and sustainable research should also be conducted on the topic of decreased implicit costs after the adoption of biodegradable plastics, and their effect on global environment and public health. With sufficient reasoning and scientific research combined with the initiative taken by branded food company, it is likely that such subsidy would be granted.

Solution’ s address upon previously identified Challenges

4.1 Economic challenge

Economic challenge, as previously identified, lies in the pricing of biodegradable plastics in assumption that the technology is not advanced enough to significantly lower the price of biodegradable plastics. The relative high pricing of biodegradable plastics can be addressed through two ways, one being lowering the price through

new technology (not considered due to the time and investment it requires) and government subsidy, the other being educating consumers on the environmental price of composite plastics and thus accept the relative higher price of plastic products.

Government subsidy would lower the price of general plastic being sold to food package in the first place. By not affecting the cost of packaging on the producer’ s side, such plan is more likely to be accepted by producers because the amount of profit they make is expected to stay the same, as the consumers is expected not to be influenced due to increased final product price.

However, with the proper implement of education, convincing consumers to accept the higher priced package is also a viable plan.

Together, government subsidy and sustainability education implementation is expected to ease the existing economic challenge over the proposed solution.

4.2 Mental challenge

Mental challenge is defined as the extent to which the new implemented plan differs from and thus challenges whether the consumers would accept the new model of food packaging in the food industry.

To introduce the model where biodegradable plastic would be responsible for the major component of food packaging, the plan would first be implemented upon big, branded food companies that has a solid consumer base and the ability to invest in the model of biodegradable plastics. Such adoption of new model would appeal to the consumers as well as other food companies’ sense of credibility and make such model more acceptable though it differs from the conventional model of composite plastic package usage.

By first introducing biodegradable plastic model to big food companies, the idea of biodegradable plastic package usage would be associated with “credible food” or “quality food” and appeals to consumers subconscious to choose food shops that uses biodegradable plastics than shops that don’ t, making biodegradable plastic associated with a higher demand from consumers rather than a challenge against the usage of normal composite plastic as food packages.

Mental challenge would also be overcome through social media content such as short documentary, art form, and photography that focuses upon environmental damage inevitably resulted from composite plastic usage and disposal, appealing to audience emotion upon choosing biodegradable plastics over composite plastics.

Mental challenge would be overcome with the credibility and influence of branded food companies and educational aspect of the solution.

4.3 Environmental challenge

Environmental challenge is defined as whether the newly proposed solution successfully addresses the existing environmental pollution resulting from the usage and improper disposal of composite plastic.

Biodegradable plastics in its very nature resolves the problem of plastic contamination from landfills and improper disposal of plastic into the Ocean. With plastics being biodegradable, plastics wouldn’ t cause micro-plastic to build up throughout the ecosystem. However, it must be acknowledged that the adoption of biodegradable plastics should be accompanied with proper management of plastic waste and control over the plastic quality. If the two approach is not conducted properly, biodegradable plastics wouldn’ t be as efficient in addressing the environmental challenges.

4.4 Physical Challenges

Physical Challenge is defined as whether bio-degradable plastic would be sufficient in providing convenience in package food transportation, heat insulation, corrosive resistance, and flexibility.

Physical challenge would be addressed by assigning each type of biodegradable plastics to the compartment in the package that can best utilize such characteristics. For instance, biodegradable plastic type that has high heat resistance would be put into hot drink packages, while those that are flexible would be used in food protection package during food delivery.

With proper design and planning of package based upon the characteristic and economic pricing of each type of biodegradable plastic, physical challenge would be addressed.

4.5 Political Challenge

Political challenge is defined as whether the solution successfully strengthened public management upon waste disposal.
The solution proposed does not significantly addresses political challenge. However, the solution can act as evidence and a model of sustainability development, which convinces the government in increased public waste management and investment over future sustainability focused project.

Solution’ s address upon previously identified root causes

5.1 Economic root cause

Economic root cause is that recycling composite plastics has a higher economic cost comparing to produce plastics, and thus recycling is not utilized, leaving mass disposal of composite plastics that led to environmental damage. Biodegradable plastics addresses such problem. Though biodegradable plastics are relatively more expensive and less common in plastic manufacture industry, they pose minimal damage to environment, resulting in a sharp decrease in implicit costs on environmental management. Biodegradable plastics successful addresses the problem of inefficient recycling, as biodegradable plastics does not have the need to be recycled and can be sustainable without being recycled.

5.2 Physical root cause

The physical root cause is defined as the physical structure and chemical composition that makes composite plastics prevalent but t unsustainable. To make composite plastics less prevalent, one approach is to set government regulations upon the proper usage and not over usage of composite plastics, the other approach being developing biodegradable plastics so that it takes over composite plastics in the food packaging industry.

The properties of biodegradable plastics would be properly utilized so that different kinds of plastics is applied to specific compartments in food packaging so that the solution is economic and physically efficient.

Biodegradable plastics are sustainable due to their nature of being degradable and thus does not stay in the ecosystem and cause environmental pollution. Biodegradable plastics, with proper design and development, would be both prevalent and sustainable, resolving the physical root cause.

5.3 Political management root cause

The political management root cause is identified as the waste treatment for disposed composite plastics, which ultimately has led to the pollution of the environment and adverse health effects. Biodegradable plastics does not usefully address such problem, as political management would have to take lead in proper disposal of plastics despite whether bio-degradable plastics is introduced or not. The introduction of biodegradable plastics would decrease the adverse environmental damage resulting from the improper disposal of composite plastics, but in long-term, the introduction of biodegradable plastics would not successfully address environmental damage that results from improper disposal of waste.

Prototype and Test

Prototype Design

Prototype Design
1. Educational perspective in school
a. 50-minute lectures would be held upon the topic of sustainability practices, environmental damage caused by composite plastics, and the nature and reasoning behind bio-degradable plastics and its disposal process.
b. Lectures that are held in school would focuses upon primary school and middle school students. The schools would first be contacted by our organization/lecture group, and then the timing will be negotiated with teachers.
c. The lecturer would bring bio-degradable plastics to class for the students to better understand the structure and nature of bio-degradable plastics.

2. Educational perspective in local organizations
a. Cooperation would be held between local sustainability organizations such as natural environment conservation organization, city planning and management organization, and water management organization.
b. the lecture would be a talk led by a lecturer, and the tone should be more humor than being serious.

Prototype poster for educational perspective of the solution

Feedbacks learnt from users

We designed a survey focusing upon the qualitative feedback from users in response to the understanding over bio-degradable plastics and environmental damage caused by composite plastics and improper disposal of plastics. Such survey, together with interview, is the basis for feedback from users.
Together, 78 people answered the survey.
The link to the survey: https://www.wjx.cn/vm/Pod643Z.aspx

1. Quantitative Feedback from the survey
a. 12.82% of people takes initiative in learning about plastics
b. 84.62% of people is not aware whether they use biodegradable plastics or non-

degradable plastics
c. 29.49% of people buy biodegradable plastic bags after the plastic restriction order is implemented
d. 80.76% of people is not clear about the definition of biodegradable plastics
e. Over the six dimensions of looking at biodegradable plastics, degradation time and Degradation cost is most frequently chosen as one of the four important dimensions when looking at biodegradable plastics.
f. People shows lack of understanding over biodegradable plastics, with 39.74% of people not knowing the main disposal way for composite plastics.
g. However, people seem to show understanding upon the adverse effects plastics has on human health and environment. 96.15% people answered correctly regarding the main harmful effect plastics has on human and the environment.
h. In context of understanding the adverse effects of composite plastic and its pollution, 30.77% of people chooses plastics due to its convenience, while the rest chooses to limit plastics usage to reduce plastic pollution.

2. Qualitative feedback from interview
We first interviewed a small, private coffee shop manager. He told us that such solution is well implemented on the educational aspect, as "education is powerful, especially when it comes to things that depends on the next generation". He also mentioned that the collaboration with local conservation organizations is "effective" and successfully draws people that are already interested in environmental protection to the action of decreasing composite plastic usage. However, manager Chen also told us that the biodegradable plastic part needs more research, as it still looks "not concrete" and more research on the market of plastic and the existing manufacturing models in food packaging industry should be research more thoroughly.

We also interviewed a undergrad student who is currently studying marine biology in University of California San Diego. David told us that he appreciates the market graph portion of the classification of types of biodegradable plastics. But personally, he wishes to see more research done upon the specific chemical breakdown process of biodegradable plastics in comparable to each other and to composite plastics. "It is me saying this from a nerd perspective" said David, "but I do consider chemical equations to be a crucial factor when it comes to the actual manufacturing process and convincing government to invest in such a project."

At last, we interviewed a high school student that has the intention to go into biology major in college. Johnny pointed out that he appreciated our initiation in proposal of such a project. He pointed out two problems. One being that there are not enough research being done on the political side and qualification required to ask for government funding, while the other being that the specific chemical

process and structure should be further researched to make the plan more applicable.

Improvement for next iteration

1. From the survey, we noticed that most respondents are under 36. It is also later acknowledged that more ranges should be divided for people above age 36 by breaking down the category into age 36-50, age 50-60, age 60 or above. By having most of the respondents under 36 due to the audience being reach out by this survey over a weeklong period, we are losing the perspective and the opinions of the people that are above 36 years old, which are a major part of purchasing force in the food market and can affect their children to a great scale if they have children.
For future improvements, we would make more effort in reaching out to older aged people and ask about their opinions upon topics of biodegradable plastics and composite plastics.

2. From the Interviews conducted, two interviewed people told us that the chemical and scientific structure and disposal process for biodegradable plastics needs more research, so that there is more convincing evidence when it comes to plan-implementation.
For future improvements, we would further research the chemical structures of biodegradable plastics, and specifically how does those structure contributes to less environmental damage and how does the structure affect the new way at which biodegradable plastics should be disposed.

3. The prototype is relative week in terms of market research and political research in process of asking for funding upon specific projects.
For future improvements, we would conduct more detailed market and political research to better understand the process involved in implementing such a solution.

4. With the survey, we know that not a lot of people is willing to get out of their way to acknowledge plastic related news or to change their habit for environmental issues.
We expect that the non-lecture educational perspective of our plan, which includes social media such as photography and videos, is more engaging and appeals to the audience emotionally that they would be willing to change their action for environmental benefits.
We acknowledge that it is uncommon for ordinary audience to put attention upon plastic related news, that means social media aspects of the solution could take lead in converting less engaging statistical and scientific data into tangible and engaging

media-based content.
For future improvements, we would produce documentaries, comic related content, and photography in aims of appealing to the audience’ s emotion to participate in certain environmental protection event or actions.

Team Credits

Jianing Yang
-responsible for the summary, Environmental part of the challenge, Generate solutions, Identify the criteria, Action plan, Prototype design, Feedbacks learnt from users, Improvement for next iteration.
-managed meetings for discussion, lead the discussion

Zerui Jian
-responsible for the the economic aspect writing of the challenge, root cause, and solution.

Yafei Wen
-responsible for the political aspect of the challenges, political management of the root cause, plastic survey, and the feedback from the public

Yuhao Liao
-responsible for the the physical part writing of the challenge and root cause.

Yiran Wang
-responsible for the mental aspect writing of the challenge and solution.

Onsite Conference File

We engaged in offline discussion session where we recorded the notes and goals for each meeting on our laptop.

Judge Comments

" Plastics and how we manage them are an ever-growing problem that needs meaningful solutions to happen quickly, in order for us to be able to protect the environment (including landfills and marine ecosystems) from being harmed. I congratulate the team for taking on this complex issue and for developing your understanding of the topic in a structured manner. Food packaging, especially, is an incredibly challenging issue given end-of-life management issues.
The team identifies some of the key barriers to proper plastics management – including the economics, essentially how it is really cheap to create and use plastics. I would suggest updating the criteria, especially economic cost, to account for whether the proposed solution is more economical than the alternative in the long run (setup + operation). In regard to the action plan, I would suggest that the best time for a government intervention (with subsidies etc.) is in fact in the very early stages, before a viable product is on the market. Companies, primarily profit oriented ones whether they are large or small, are more willing to pick up products that are viable. Similarly, economic theory suggests that government subsidy that reduced price to producer will eventually reduce the price to the consumer and they will see the saving as the producers won’ t be able to capture the price difference for too long.
Some more thought could be given to how best to engage the industry with alternatives, and consumers outside of the school. All in all, the team did a great job thinking through how to make change and have taken the first steps toward developing concrete actions towards it.
"