Sustainability Innovation

Strategies To Alleviate Marine Plastic Pollution Caused By Disposable Masks During The COVID-19 Period

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Summary

The ocean has changed. It was once an upside-down sky.

More than 300 million tons of ocean plastic are created every year, causing 100 million marine animals to die. Plus, the sun radiation resulted in the plastic break down into smaller fragments, forming microplastic that might be eaten by marine animals that people will possibly consume. Additionally, in the situation like Covid-19, where 1.56 billion face masks, using non-woven fabrics (type of plastic)as its primary material, were entered different parts of oceans: as it harms marine life and impacts marine life Apparently, actions should be triggered towards this significant global issue, plastic pollution. Our team aims to conduct a solution through online searching, brainstorming, data collecting, and practical experimenting. Additionally, through Sustainability Innovation, we hope our idea and design could alleviate marine plastic pollution, improve the marine ecological environment, and promote sustainable development of marine resources.

Firstly, our team was distributed into groups analyzing the challenges we may confront related to the face masks; we found out its cognitive bias, disposal and classification awareness, convenience, knowledge on wearing, education, emotional issues and the cross-boundary collaborations essentials of the problem.

In order to centralize the issue, we concluded all those challenges are originated in three root causes: The occurrence of the pandemic, the lack of government intervention and the characteristic of plastic in the use of masks.

All the further research and experiment will be concentrated into the three perspectives; thus our members are allocated into three groups, and came out eight solutions in the aspect of new material design, public education and cleaning process.

Then we evaluated those possible solutions by the perspectives of its effectiveness, economic concerns, sustainability, previous development, and opportunity. The one who got the highest ranking out of 25 marks will be the best solution.

After the group discussion, we decided to make the idea of gene-modified Cylindrotheca closterium that could biodegrade plasticizers and self-control growth practical. The article has mentioned its sufficient detail, including its fundamental technical background, its advantages that are different from other products, its

funding, its consumer and others to prove the feasibility of our design.

Moreover, we have also designed the specific policies and implementation in the experiment, and we made a questionnaire and collected the feedback from the consumer, demonstrating our product from another perspective.

There is a lot of space to improve, including its number adjusting ability, its impact on ocean animals, and human constructions' influence. In the future, we will conduct further research and experiment to improve our product and dig deeper into a particular area. We hope our product can be implemented in the ocean if necessary,

Hopefully, we can use our strength to alleviate marine plastic pollution and creating a sustainable future.

Choose the Topic

Identify the Challenges

1. Cognitive Bias on Facemasks
Cognitive bias is a phenomenon describing individuals inaccurately and subjectively judge something from their perception of the input. Because of the accidental outbreak of COVID-19, most people are not fully aware of the right way to use facemasks or even gather the usability of masks from common sense. Such bias or lack of knowledge on facemasks indirectly creates the difficulty of classifying and recycling facemasks and further brings an impact on the deterioration of marine pollution.

1.1. Lack of Disposal and Classification Awareness
Insight to the global situation, apart from dumping in the mixed waste containers, people committed some common improper disposal mistakes, such as flushing in toilets, burning, or even directly throwing them away. Those inappropriate disposal behaviors combined with mixed waste occupy 70% of used facemask disposal, which essentially increases the difficulty of mask decompositions and the prevention of marine facemask pollution, especially in coastal regions, as different trash undergoes different procedures of disposal. Suppose some facemasks only undergo landfill (the common way to deal with dry and household waste) rather than incineration. In that case, the partially decomposed plastic fragments could possibly flush by rainwater into the drainage system and further contaminate the groundwater and marine ecosystem.

1.2. Inconvenience of Disposal of Masks
Classification of used masks is essential to the subsequent disposal stage. Refers to the document "Notice of the General Office of the National Health Commission on the Management of Medical Waste in Medical Institutions During the Covid-19 Epidemic" published on 28th January of 2020, the Chinese government has specified that any waste produced by medical institutions in diagnosis and treatment of patients with pneumonia infected by the new coronavirus and suspected patients in fever clinics and quarantine units (rooms), including medical waste and household waste, should be collected in accordance with medical waste. However, rarely have people recognized that all facemasks should be disposed of in a particular or medical waste container, or not the dry and non-recyclable waste container, or even the recyclable one, which makes the disposal of facemasks far more inconvenient. Until now, even though most public institutions like schools and shopping malls have set up provisional mask containers for people to dispose of masks only, according to the survey taken on 22nd April 2021, there are still 59.8%

of people could not find any specific container for used masks nearby when they would like to trash their facemasks, especially in their own residential community. The particular container is necessary for two purposes: First and foremost, it ensures that the risk covid infection is centralized, that everyone who accesses the container is aware of the fatalness or risk factors; On top of that, all the used masks, including polypropylene can be disposed by incineration intensively in order to prevent circulation from local water area to groundwater and finally to maritime space. Once the local or central government organizations and related staff recognize its demand and significance, mask pollution can be effectively alleviated.

In addition, the common disposal way of used plastics (facemasks) is no longer reliable in the current situation. Common plastic waste management includes three essential "Rs", which are "Reduce, Reuse and Recycle" (refers to the image "Waste management hierarchy" in the attachment; however, as will mention below, the degradation-resistant property of non-woven fabric and facemask (prevent Covid-19 infection) itself makes the use of the product cannot be reduced, reused, nor recycled. Therefore, special waste management should be employed. Normally, all surgical masks are disposed of as clinical waste and delivered to Chemical Waste Treatment Centre for incineration at a high temperature of about 1,000 degrees Celsius. All the emissions will be treated by advanced air pollution control equipment to ensure compliance with the stringent emission standards to protect the environment. In fact, since there are existing difficulties in primary disposal and classification, aggregated disposal of all facemasks seems unpractical.

1.3. Lack of Knowledge on Wearing Masks Properly

The severity of marine facemask pollution doubles since the outbreak of the COVID-19. About 0.39 million tons of debris could end up in the global ocean annually, and the misunderstanding of facemask wearing considerably contributes to that number. Because of the panic in front of the pandemic, people would trust in some persuasive but unscientific methods of wearing facemasks, not limited to wearing two masks could enhance prevention of the coronavirus, or facemasks with exhalation valve are more effective on prevention. All these statements have been falsified, that they are not only less effective on filtering pathogens than imagined but also create more plastic waste, while the masks with exhalation valves require more polypropylene in production; consequently, more plastics will be in the disposal.

1.4. Education Around Disposing of Face Masks

In January 2020, the Chinese government announced a phased ban on the usage and production of various single-use plastics to solve environmental pollution issues, and planned to be performed nationwide by the end of 2022. However, the necessary protection to COVID-19 became an obstacle and unconsidered factor which severely interrupts the ban.

With the increasing usage of disposable masks and the wastes caused by services such as ordering and delivering the masks, the pandemic has risen both social and environmental concerns for society. With the environmental pollution, COVID-19 has double burdened the Chinese government not only as a health emergency. While the Chinese public has a positive attitude towards wearing face masks, the Chinese government has not yet established an efficient way for disposing of the masks. According to China Youth Daily, even though it is announced that there will be a special location of collection points for used disposable masks, 59.8% of those surveyed are not able to find or have access to the location; 49.9% believe that the Chinese government still lacks a scientific and reasonable approach to the disposed masks; 72.9% suggest that there should be a special garbage can in every household for disposing of masks. Furthermore, 71.6% of those interviewed believe that it requires more education and advocation to raise the awareness of appropriate ways for disposing of face masks. Moreover, there is not only an unfinalized system for disposing of the used masks, the government is also facing the increasing issue of pollution in the ecosystem and especially water bodies caused by the existing wrongly disposed masks. Thus, there has not been enough effort to change the current situation and issue around disposable mask pollution and a detailed solution to track and dispose of all the masks correctly so far.

1.5. Emotional Issues and Negative Attitudes Towards Facemasks

As the disposable masks effectively prevent the spread of COVID-19, there have been various reactions to the policy and encouraged behavior of keeping masks on around the globe. "Positive emotions become less recognizable, and negative emotions are exemplified". One of the main reasons for this situation is the lack of education by government and institutions around the world at the early stages of the pandemic, which gave chances for more conspiracy theories and unscientific mainstream opinions and reactions towards facemasks. Additionally, there have been behaviors of overconsumption of masks as a panic-driven response to the pandemic especially in countries with positive attitudes towards disposable masks, such as China. With the lack of awareness and education regarding production status and capacity, the herd effect has performed in the early stages of the COVID-19 pandemic in 2020. The insufficient and sluggish pace of public education creates the hotbed for unfavorable voices and behaviors and is even detrimental to the world to recover from the pandemic.

2. Masks in the Ocean

When the masks flowed to the oceans, destructive results emerge, including the polluted water body, marine animals killed by the accidental ingestion, humans be hard with the microplastics inside the aquatic products.

2.1. Marine Ecology

During the COVID-19 period, it is estimated that more than 1.56 billion facemasks have entered the oceans. Because masks look like food, such as jellyfish or algae, many aquatic organisms might take the masks for jellyfish or algae so their esophagus will be blocked by the masks and their body will receive serious damages. Some of them are killed because their stomachs are full of plastic, others died for they cannot eat or breathe because of the barrage of masks. What’s more, the wires on the masks might also twine sea birds’ necks to stop them from inspiring. Each year, more than 100,000 marine mammals and countless fish are murdered by ocean plastic. The number of dead birds is over 1 million as well. The loss because of the death of animals is worth 13 billion USD per year. Additionally, the chemical components of masks such as heavy metals harm animal's function as well. Dr. Chelsea Rochman, a professor of Ecology at the University of Toronto, who mimicked the influence on plastics to fish by feeding a common fish, Japanese medakas, with polyethylene, a component of plastic, found the weakened digestive system and decreased numbers of eggs and sperm on the subjects after two months.

2.2. Human Society

Besides the danger to marine animals, the challenges appear also to our human society as well. After being radiated by the sun, the intact masks are separated into pieces that are smaller than one-fifth inch’s size, called microplastic. It might be eaten by marine animals that will possibly be consumed by people. In 2008, the experiment conducted by Browne, a scientist that was studying the impact of plastic pollution, showed that the plastic consumed by an animal wouldn’t be easily excreted, which means it stays in their bodies for an extended period of time. And because of bioaccumulation, the amount of plastic intake quantity can be hundreds of times greater than that of a single fish might contain. The water and air we intake every day might also contain microplastic. A study published in April of 2018 asserted that researchers have found microplastic in drinking water and sea salt, proving that plastic pollution is an actual threat. After intaking the microplastic, human organs will be harmed, for example, it compromises immune function and stymies growth and reproduction. The food chain might also be influenced, which means our food source may be limited. Whereas it is still hard for us to clean masks in the ocean. Because it is widespread and small, we don’t have an exact strategy to handle this problem. For now, there are more than 15 trillion tons of plastic on the ocean surface, creating a potential global health issue.

3. Cross-Boundary Collaboration

In order to solve marine issues, a cross-boundary collaboration between different countries and various stakeholders is an essential part of the challenge. The stakeholders include governments, researchers, education, media, the plastic industry, NGOs; and other industries such as shipping, fisheries, and agriculture. Since the "marine environment is a common good", global cooperation is needed since the ocean belongs to everyone meaning that everyone shares responsibility for solving the marine issues, including plastic pollution from face masks. However, there are several difficulties and complex tasks through this process. First, this process involves a variety of negotiations of international agreements and regulations. The setting of these is time-consuming for reaching an agreement. Next, it is a complex process for these regulations to be implemented and establish a monitoring system.

Moreover, these practices enforced by global regulations need to cooperate with local regulations for being effective. One of the main challenges is that NGOs, other non-state actors, and industries also play an essential role in the issue of plastic pollution in the marine environment. While NGOs target specific sectors such as the plastic industry and cosmetic industry, it is fundamental but challenging to encourage initiatives to take responsibility and take the lead instead of the governments to protect the environment and improve their means of production. These responsibilities include a financial obligation, legal responsibility, and most importantly, social responsibility. While this cannot be an alternative for the role of government, it can build regulatory frameworks for the society and the government to work with.

Meanwhile, the other challenge is the society, the citizens and consumers, which is an important stakeholder in this issue. Due to the nature of this issue, most people do not feel engaged or connected with the marine environment. Currently, society is facing the challenges of educating the public and raising awareness to help everyone recognize the issue. By raise awareness, there are smaller groups of individuals especially children, whom the society needs to educate so they will grow into responsible individuals and become a generation who are aware.

Disposal method of mask waste
Waste management hierarchy

Identify a Root Cause

1. The Pandemic
Due to the outbreak of COVID-19, the disease affects our health and global health care and the economy and environment of our world. To control the spread of COVID-19, face masks, especially disposable masks, have become an essential part of our daily lives as primary personal protective equipment (PPE). Since the pandemic's beginning, there has been a significant increase in the demand for masks, which creates millions of tons of plastic wastes within a short amount of time.

Specifically, the pandemic has increased the exports of disposable masks and disinfectants by more than 1000% from 2019 to 2020. Based on Statistics, the market size of face masks in China has increased from 27.07 billion yuan to 71.41 billion yuan with a growth of 164% from 2019 to 2020. With the vast increase in the production of masks and the supply shortages, there is a lack of attention from the government and society around the increase in plastic waste and how these "unrecyclable" products are disposed of.

2. Lack of governmental awareness and intervention
With the suddenly increased usage of masks due to pandemics, many issues are now worth consideration from the government but mainly ignored.

Not mentioning the landlocked country's (such as Bolivia and Paraguay in South America) awareness about the severity of marine pollution driven by inappropriate disposing of mask plastics, even coastal countries' current regards of marine plastic pollution are far from the attention put on the Covid-19 pandemic (which is understandable in this situation); however, feasible and detailed policies should be soon enacted to prevent deterioration of the plastic pollution caused by masks.

Indeed, it's undeniable that several organizations, corporations, and governments were aware of the issues mentioned above, says the government of Island on the International Symposium on Plastics in the Arctic and Sub-Arctic Region, "There is a fundamental need to move to circularity and resource efficiency. In this regard, we have the science and technology to prioritize and fast-track innovative upstream and downstream interventions. But we must be aware that there is no one-size-fits-all solution. There are many variables and difficulties that need to be tackled, which require government intervention in terms of funding and legislation, as well as collaboration between governments and other organizations. Once an adequate system to deal with these issues is applied, a number of considerable problems can be resolved. Different geographies and different plastic categories require different solutions." Apart from intervention in the practical field of alleviating marine mask pollution, intervention in the people's cognitive bias and emotional response is also needed to a large extent.

3. Characteristic of plastic in the use of masks

The mask such as KN95, N95, and medical masks we used to prevent Covid-19 infection has the structure of three layers, also known as SMS structure (refers to the image-structure of common masks)——Leakproof of non-woven fabric at the outmost, high-density filter layer in the middle, and direct contact skin layer. Specifically, non-woven fabric is a fabric-like material made from staple and long fibre rather than clothes; it is bonded together by chemical, mechanical, heat or solvent treatment, and the fibre utilized in the production of masks is polypropylene, which is capable of filtering 95% of particles about 2 micrometers. Additionally, it's non-toxic, hydrophobic (water-fearing) and inexpensive, also contributing to the reason why masks are affordable to most people during the Covid time. (Normally when demands exceed the supply, the price of masks will increase but until now masks are still low-cost.) This also indicates that there are rare or no existing substitutes to replace the role of polypropylene in the production of masks.

On the other hand, masks made of polypropylene cannot be considered reusable. The World Health Organization (WHO) recommends removing a mask once it is damp from your breath, and never reusing a single-use mask. Because these masks act as a physical barrier against respiratory droplets and germs, they can also transfer those particles onto other surfaces. This characteristic of such disposable masks produces a large amount of waste as a direct result.

Once plastic waste enters the ocean, it will be broken down into microplastics with diameter of less than 5mm by the endless ocean dynamics like the tide. This form of plastic will spread farther and deeper in the ocean and invade more biological habitats. In fact, it seems impossible to recollect and recycle those microplastics which cause the current exacerbated pollution.

Last but not least, the interaction of plastic with aluminum sticks on the facemasks creates far more severe pollution as they enter the marine ecosystem with toxicity which is hard to deal with. The consumption of aluminum is very high reaching as high as 5.4 million metric tons in the United States in 2017 alone, consisting of the use of aluminum sticks on every single facemask. The release of aluminum to the aquatic environment occurs through both natural and anthropogenic forms. There has been a proven negative impact of aluminum on a number of beneficial freshwater algae species. However, freshwater algae are crucial to maintaining a healthy synergistic ecosystem as they increase the bioavailability of dissolved oxygen for the organisms underneath.

Structure of Common Masks

Generate Solutions

Solution1: Dealing the Masks Already in the Ocean
1.1 PEM
The full name of PEM is Plasma Enhanced Melter, which is a terminal solution to nearly all kinds of waste, including all parts of the masks.

The PEM is a device that uses plasma to process, recycle and reuse most kinds of waste developed in the 1990s. Researchers at MIT have developed this technology for an extensive period. The reliability of PEM has been proved and it's still improving. Now there are 13 PEM facilities in the world, including G100P in Columbia and G100 in Taiwan.

The working principle of PEM is apparent: it uses electronic plasma to heat the waste in the containers so that the chemical composition of the waste is changed to use clean energy gas. There are several steps to accomplish that. First, the waste will be mixed with oxygen and steam. The mixture is heated to 800-1200 Celsius degrees. In this stage, the combination is generally turned to cleaner gases and the product, called syngas, will be used in the following PEM step. Then is the second step. The Plasma Enhanced Melter will be put into the device to raise the temperature further. The PEM can produce very hot electronic arcs that reach ten thousand degrees. The area around it will get to 5000 degrees, and the heat transformed to the waste container will make the temperature vary from 1200-1400 degrees. Such a harsh temperature can completely turn the remaining waste into clean and flammable gases since its extreme particle movements already break the chemical bonds and it is converted into a new substance. After that, the remaining time after PEM's heat is released and the temperature keeps 1400 Celsius degrees can also be used to entirely destroy the tars and oils of the waste in the Thermal Residence Chamber, further improving the usability of the raw syngas. Subsequently, the raw syngas will go through standard industrial preparation for energy use and reprocess the inorganic part of the waste.

After the initial processes, the consequential product can be used as clean energy or industrial material, like hydrogen and ethanol. One of the best characteristics of PEM processing the waste of mask is it doesn't require much pre-operations like separation or classifying, which primarily reduce the financial and labor cost of dealing with the garbage. And this property is because the high temperature of PEM changes the chemical bonds of substances, making it able to recycle whatever kinds of material in the container. So the PEM is very suitable to deal with masks in the ocean during COVID. We need to make slight changes to the original device to suit the wet condition better. This change is plausible because of the announcement on a website called "SeaChange." It states that the PEM device on their ship will be able to deal with 2 tons of waste every day, making significant changes if there are more ship numbers among the oceans.

Compressed, the overall plan of using PEM is to set diverse ships among all the seas that have severe plastic pollution worldwide. And since it can produce part of the fuel for operations and ship-driving by processing the masks, it is environmentally friendly.

1.2 The enzymatic-bacterial approach

For enzymatic treatments to work, we must identify and mass-produce the enzyme targeting the breakdown of plastic in facemasks.

The most well-known and studied enzyme that targets plastic is the PETase (polyethylene terephthalate-ase), a hydrolase naturally occurring in both the bacteria Ideonella sakaiensis and the fungi Pestalotiopsis microspora. These enzymes have the ability of targeting and create breakage in the molecular bonds of plastic in plastic bottles, breaking polyethylene terephthalate into Terephthalic acid and ethylene glycol, in which other bacteria could break down both resulting molecules into CO_2 and water. The PETase is able to catalyze the natural breakdown of PET from years down to days. However, the plastic in face masks is different from its counterparts in bottles. Most conventional masks are made up of three layers. The outer layer is mostly polypropylene, including significant amounts of other plastics such as polyethylene (not PET!) in the inner layer. Unlike PET, polypropylene is an aliphatic hydrocarbon, an open chained hydrocarbon containing no rings and is not aromatic. Unfortunately, PETase is incapable of breaking down aliphatic hydrocarbons. Thus, to use the enzymatic approach in solving the plastic pollution created during the covid period, we must either find naturally occurring enzymes that could break down plastic or artificially generate one. Ideonella sakaiensis was also discovered at a landfill in Japan, so it is probable that bacteria with adaptations of being able to break down polypropylene and other plastic compounds in face masks using enzymes already exist in some other plastic-rich environment; however, creating an enzyme would probably be more effective and reliable since we already have the model of the PETase that we could make modifications on to suit our purpose, and equally efficient. We would use polypropylene as the targeted plastic for breakdown for the below methods, as it constitutes the most mass out of all the plastics in face masks.

After we have figured out the chemical composition of the enzyme that can break down polypropylene, the only thing left is to distribute them into the ocean. There are two ways of doing so, both using bacteria. But first, we need to add the gene of the new enzyme into the bacteria's genome so the bacteria could synthesize the enzymes for us, and it isn't hard considering the recent advancements in CRISPR and NGS technologies, which places the targeted gene into a vector that transports and splices the gene onto the actual bacterial genome.

I. To mass-produce the enzyme
The first method is to create vast genetically engineered bacterial cell cultures. We would grow the cells and harvest the enzyme, similar to the process of harvesting antibiotics (e.g. penicillin) from bacteria cultures. The first method's gene must be designed to have a promoter, or a transcriptional factor activated by the binding of the "polypropylene-ase" or its subunits. This ensures the creation of a positive feedback loop, where the synthesis of the enzyme would lead to even more production of the enzyme, ensuring maximum yield. The environment of the bacteria should also only contain mostly polypropylene to further stimulate the synthesis of the enzyme. After the concentrated enzyme solutions are collected, they could be released onto plastic pollution-infested ocean surfaces to break down polypropylene, like placing medicine onto earth's wounds. Since enzymes are highly reusable, the enzymes distributed would continue functioning for years to come. Growing the bacteria cultures would also be able to consume large amounts of plastic. This method is financially and environmentally efficient, as the bacteria can quickly synthesize abundant quantities of enzymes. In addition, since the whole process is in a lab setting, and we could use readily available and reliable bacteria such as E.coli, the process is rendered to nearly the difficulty of routine cell cultures. The short-term effects of this method will be astonishing due to the high level of enzyme output.

II. To cultivate an oceanic plastic-consuming bacteria population
The second method is essentially no different, and however, instead of the enzymes, we would release the cell cultures themselves into the ocean and break down the plastic, which theoretically brings more benefits since because bacteria use polypropylene as an energy source, the more plastic present, the more abundant the food source, the higher the bacterial growth will be. In other words, the bacterial population would fluctuate according to the severity of the plastic pollution, maintaining homeostasis. In this method, the gene received by the bacteria must contain conventional activation systems that synthesize enzymes according to the bacteria's needs, such as a negative feedback system, where the binding of the polypropylene serves as the deactivator(inducer) of the repressor to the gene expression, as the mechanism of the Lac operon. This is because we want the bacteria population to be sustained and thriving in the ocean according to the pollution. Thus, the bacteria should treat plastic-like glucose and lactose's equivalent, and only produce its "utensils" when they need to consume and break down plastic, or else they might die of wasting protein polymers on the making of these enzymes. Since there are also many other nutrients in the ocean, the bacteria

could also be modified to prefer the plastic over other nourishments, which we could do by adding a repressor mechanism to the genes of other nutrient-breakdown genes, where the binding of polypropylene-ase would result in their deactivation. The benefits of this method are that its effects are long-term, continuously controlling the breakdown rate and sustaining the bacteria until most plastics are degraded. Although there are many factors to consider during the addition of the gene and will need many modifications to other genes in the bacteria, the choice of bacteria is much more specific, and it costs much more than the last process in the first one, there will only need one deployment of the bacteria to sustain the plastic degrading process.

It is most beneficial to use both methods simultaneously. The plan is to grow the bacteria and the concentrated enzymes and distribute them mainly in the heavily polluted areas, such as the Great Pacific Garbage Patch, and other parts of the ocean, evenly released across a region. The distributed regions will receive tests in pollution improvement every half year, and painful areas such as the Great Pacific Garbage Patch could also use aerial observation to identify improvements. Being a solution that creates theoretically no additional drawbacks, the bacterial enzymatic approach could become widely utilized in environmentally friendly plastic treatments.

1.3 The River Inspectors

A large portion of plastic wastes comes from rivers. In fact, rivers are responsible for 80% of all the waste transmitted into the ocean, which means we can significantly reduce the amount of waste by blocking upcoming garbage in the rivers.
The inspector is a solution to this.

The working principle of this inspector is simple. It has a set of barriers located on both sides of the rivers; they leave some space for ships to go through while leading the waste to the collectors. Then the collector, which is motivated by the solar panels on it, can use the track and belt to transport the debris to the collector. If necessary, we can also place an automatic shuttle to categorize various waste and plastic. After the collector is completed, the inspector system will message the local managers to deal with the existing garbage. Because of its easy operations and neutral energy use, it is sustainable.

The advantage of the inspector is that it can be built on an immense scale to handle the plastic of all the rivers, and it is relatively cheap for governments to build. It is very efficient when collecting pollution and masks. What's more, it is practical to make because it doesn't need any advanced technology. In fact, there are already several inspectors in different countries. The one in Indonesia can collect tons of waste and make remarkable changes to the local environment.

1.4 Gene-modified Cylindrotheca closterium

The Gene-modified Cylindrotheca Closterium is another solution that could biodegrade plasticizers and self-control growth.

I. CRISPR—Gene editing of Cylindrotheca closterium (Figure 1.)

The CRISPR/Cas9 technology has been successfully applied to micro-algae and is theoretically feasible for marine microalgae. It has been shown that codon optimization of exogenous genes and endogenous strong promoters can improve exogenous expression vectors' efficiency in algae, with a preference for G and C due to the high GC content in the algal genome. The following studies have been conducted to guide micro-algae improvement in three areas: optimization of transfer vectors, selection of genetic transformation methods, and improved editing efficiency.

II. RSTP—Resilliance Symbiotic Termination Protocol(Figure 2.)

We decided to use CRISPR gene-editing technology to cut and transfer the genome sequence of PAL and C4H which synthesize pCA. This process is called RSTP. PAL and C4H would only express when the first-generation algae died. Indeed, there is a parasitism relationship between algae and bacteria shown by the picture. pCA acts as the elicitor to help bacteria release anti-algal compounds and control the growth of Cylindrotheca closterium. Hence, with the help of Phaeobacticides, we could control the growth rate of the microscopic algae to optimal. Moreover, Cylindrotheca closterium is a kind of algae which are capable to grow in high salty water. Thus, this special characteristic enables our product to applicate in an especially wide range, solving the PAEs problem in the ocean. Once PV-AL has been put into the ocean, it will function naturally. This is a protocol that automatically controls the algae population. Implementing this system would reduce the risk of our product to nearly zero. Making our product truly eco-friendly.

III. Sodium alginate & Calcium lactate eco-friendly Reaction to make the eco-friendly package

Sodium alginate, a natural heteropolysaccharide extracted from brown algae (kelp, etc.), is often used as a matrix for packaging and delivery of other active ingredients due to some of its unique properties; as a food ingredient, it can form calcium alginate gel films
with calcium ions under specific conditions. The film has some gas-selective permeability properties and can be used as a micro-algae storage container by creating a nearly closed, self-contained environment inside. In PV-AL we will use this property of sodium alginate to chemically react with calcium lactate solution, making our environmental protection packaging.

Solution 2: New Face-masks Material

2.1 Non-thermal Plasma

Non-thermal plasma is a category of plasma technologies combined with printed electronics to enable the safe reuse of single-use personal protective equipment (PPE), that's disposable masks here, as Dr. Min Kwan Kim from the Department of Aeronautical and Astronautical Engineering from the University of Southampton attempt to tackle shortages and the mountain of excess waste generated throughout the coronavirus pandemic. Specifically, it's a plasma brush and a ground-breaking dry decontamination method that can be used to treat face masks and respirators which might have been in contact with the coronavirus. Since even surgical masks are made to use for a single time, they can still be reused for a limited time if there is no risk of contamination from infectious particles on the surface. This will contribute to the alleviation of marine plastic pollution less waste is generated.

Previous research has demonstrated non-thermal plasma's ability to inactivate 99.9% of various viruses. However, it has not been widely used for viral decontamination because it is difficult to generate uniformly over large surface areas. Furthermore, it needs a non-ambient carrier gas such as argon or helium. However, recently, researchers overcame these problems using a new plasma creation scheme with the help of printed electronics to create the non-thermal plasma. While they implement a microwave scattering method to measure the energy intensity of plasmas and transmission electron microscopy to detect alterations in the virus, it seems possible that disposable masks are no longer "disposable" but reusable after a period of time.

Solution3: Media Communication

Candidly speaking, it is essential to solving the problem from its awareness—— Human Beings. Raising peoples’ awareness and teaching people the right things to do is the kernel preventing more and more masks contaminated in the ocean, causing our health and other marine lives. Aiming for awareness, media communications would be one of the best solutions it can be. The governments or NGOs (Non-governmental Organizations) could publish articles, videos and other advertising forms through Wechat official accounts, Instagram, YouTube and other social media; by writing the consequence towards our own community and society if no actions are triggered for proper treatment of disposable masks. Simultaneously, we would like to encourage residents to start from themselves and start from small things, including how to fold the masks once abandoned and where to put the masks when used.

Solution 4: Recycling Method of Masks

Recycling the used masks can significantly decrease the pollution created by the disposable materials in masks, so we plan a process for recycling the used masks.

According to the program from teracycle, one thing has to be emphasized is that if the masks cannot be reused for several time, then they cannot be recycled to a mask after they have been used. Moreover, suppose a mask is polluted by blood, or is used in hospital or medical service places. In that case, people should directly deal with them like burying or burning because the bacteria and virus might strongly affect other wastes during the process. People cannot know if they are still there after the recycling process. The masks that people want to be recycled will be collected together and experience a quarantine for 72 hours. This step aims to observe the virus and bacteria activities. After that, the recycling processes are happening upon the component of masks, for example, the plastic inside, the metal and the elastane or rubber band. Each different piece will experience a different process. The hardest part to degrade for plastic will be densified into a crumb-like raw material used in plastic lumber and composite decking applications. For metal, they are manually removed and sent locally for smelting into new bar stock and metal sheeting. The deal is to ground the elastane or rubber band into a fine-mesh regrind and mix it with recycled plastics as an additive to provide flexibility and malleability to products.

🗎 Gene-modified Cylindrotheca closterium could biodegrade plasticizers and self-control growth

🗎 PEM sketch

🗎 CRISPR genetic engineering mechanism

Identify the Criteria

1. Effectiveness (Influence scale)
-How many marine plastic litters can the solution dispose of? (In terms of quantitative and qualitative data)
-Will geographical factors affect the effectiveness of the solution? Can the solution employ globally or only regionally?

2. Economic concerns
-What is the cost of the solution's research and experiment?
-Is there any hidden opportunity cost?
-How much human capital does the solution require?
-What is the future maintenance cost?

3. Sustainability
-Will the solution cause new environmental concerns?
-Will the solution become less effective as time goes by?

4. Previous development
-Is the solution still in the experimental or research and design phase?
-How much further effort should the stakeholders put in order to deal with the issue? (eg. Legislation, cross-boundary collaboration, promotion and etc.)

5. Opportunity
-To what extent is the solution being welcomed by the people?
-Will the solution be conflicted with any belief?

Evaluate the Solutions

1. PEM
2+3+3+4+4=16
Strength:
1. This technique has been highly developed and mature enough to begin operation since the theory was proved a long time ago, and went through several lab-based experiments.
2. It has nothing to do with ethical issues.
Weakness:
1. It can only be applied within a certain scale, in terms of being solely capable to deal with a certain amount of plastic waste within a period.
2. The technique has advanced demand in repair and upgrading costs.

2. Enzyme-bacterial solution:
4+3+5+2+4=18
Strength:
1. The solution is a very eco-friendly and sustainable solution that will not interrupt the marine ecosystem.
2. Except for putting enzyme or bacteria in the riverside/lake/ocean areas, it does not require further manual work in terms of extra demand in human labor.
Weakness:
1. It's still a theoretical solution that is based on scientific hypothesis in the ability of decontamination that several lab works are required before entering the market.
2. Related lab works such as enzyme culturing and genetic engineering could be financially draining.

3. Non-thermal Plasma
3+3+5+4+4=19
Strength:
1. It's already at the end of the research phase which means it can be employed realistically within a short period of time.
2. it enhances the reusability of the masks, which will prevent a large number of mask pollutants enter the ocean (pollution will be halved or even less).
Weakness:
1. Although it proved to be effective in inactivating 99% of viruses, it's unpredictable whether it will be able to reuse in front of Covid-Delta mutation
2. People may not think it is as trustworthy as disposable masks.

4. Inspector
3+4+3+5+3 =18
Strength:
1. This technique has been highly developed and mature enough to begin operation.
2. it is friendly to the animals in the river and doesn't modify environment much.
Weakness:
1. It can only solve the pollution problem on limited scale.
2. It is not sustainable enough to solve the problem permanently.

5. Recycling method
3+3+2+5+3=16
Strength: It does not require new technologies; there are some companies in developed countries offering this kind of service; this is a volunteering program currently.
Weakness: It has to be employed wide enough in order to prevent flow of plastic waste from all riverside areas to ocean.

6. Plastic cleaning machine
3+4+5+4+4=20
strength:
1. It's environmental friendly since it uses solar panels as an energy source.
2. It can set in a wide range of plastic collecting regions (suspending and floating plastic, 700kg each time)
3. It is relatively cheaper than other common solutions.
weakness:
1. It's a common idea that could be raised by local government before but failed to apply.

7. Gene-modified Cylindrotheca closterium that could biodegrade plasticizers and self-control growth
5+5+5+3+5=23
strength:
1. There is a high sustainability with the algae group being able to control its own evolution
2. It lasts for long term.
3. It shows adaptability to all types of water bodies;
weakness:
1. It's a new idea that requires more experiment with the product in order to know its actual impact on the marine ecosystem.

All solutions are evlatuated according to the rubric made according to the content in "Identify the Criteria" and added in the attachment.

Rubric of Evaluation of solutions

Make an Action Plan

1. Introduction

Unlike the current ocean plastic cleaning machines and other standard products, our innovation using the special algae consists of the following superiorities: its eco-friendliness, its virtuousness, and, more importantly, its efficiency.

The energy consumption and other side-effects of the cleaning machines, especially those petroleum-driven, overweigh the process of cleaning and collecting waste. However, the eco-friendly algae could be treated as the “organisms” which would not generate extra pollution or burden.

Also, creating a virtuous cycle towards the marine system for sustainable future development is essential: the algae would grow and duplicate by absorbing organic pollution, heavy metal, and pervasive plastic without producing any toxins.

Undoubtedly, the efficient work of the capable algae in cleaning the plastic on various scales will be implemented in the ocean, where they automatically disperse to consume more plastic. The light and tiny algae are likely to be carried by the ocean currents to expand their operating range, including certain width and depth.

Thus, our action plan aims to apply the algae into the plastic- and mask-contaminated areas in order to clean up those wastes by the algal digestion and degradation.

2. Technological Concepts
2.1.1. Reliance Symbiotic Termination Protocol.
Our product could directly solve the oceanic PAEs problem by targeting two prevalent plasticizers — Dibutyl Phthalate (DBP) and Dimethyl Phthalate (DMP). DBP and DMP are highly toxic, hardly degradable, and widely distributed, so they could be accumulated in organisms to cause serious damage to the reproductive system, biological development, hormone secretion, and gene expression. Therefore, we have applied the Cylindrotheca closterium, a eukaryotic alga capable of biodegrading both DBP and DMP.

In recognition that algae are a diverse group of uni- and multi-cellular plants, we have considered those undesired and uncontrolled consequences of the algal blooms. All common strategies to control algal growth, including active chlorines, copper-containing compounds or quaternary ammonium salts, contain toxic and corrosive chemicals, so, to satisfy the need for safer algicide, we have designed a brand-new protocol — Reliance Symbiotic Termination Protocol.

2.1.2. Host Algae to Degrade DBP

Cylindrotheca closterium is a eukaryotic marine alga whose average division rates on day 2 were 2.34 div. d21 in the unstirred treatment and 2.51 div.d-1 21 in the stirred treatment. The average division rates had dropped to 1.84 div.d21 and 1.96 div.d-1 21, respectively, by day 3 when the cultures were closer to entering stationary growth. Student tests revealed that the observed differences in the growth rates between the two treatments (n 54) were not significantly different on day 2 (p 50.227) or day 3 (p 50.08). Once the stationary phase growth was attained by day 6, the average growth rate of the unstirred treatment (1.08 div.d-1 21) was significantly greater (t-test; p 50.02) than that of the stirred treatment (1.02 div.d-1 21). And during the metabolism process of Cylindrotheca closterium, DBP is used as a growth substrate to support the division of Cylindrotheca closterium cells. In theory, the concentration of DBP will be reduced when Cylindrotheca closterium grows to a specific amount.

2.1.3. CRISPR: Gene Editing of Cylindrotheca Closterium

CRISPR technology is a gene-editing technique for adding, deleting, or replacing bases in specific DNA fragments in the genome. Nucleic acid endonucleases and specific proteins play important roles in gene editing: nucleic acid endonucleases are widely used for the targeted DNA cleavage by recognizing and cutting certain DNA sequences, and specific proteins, such as zinc-finger proteins and Cas9 proteins, have similar functions. When the targeted sequence is cleaved, the cellular inherent non-homologous end-joining (NHEJ) repair process joins with those fusion proteins, leading to targeted insertion, deletion or shift mutations genome, causing exogenous DNA insertion and gene function loss.

With the rapid development of high-throughput sequencing technology, several marine algae genomes have been sequenced, including the brown algae Saccharina japonica Ectocarpussilicu- loss, the green algae Chlamydomonas Sinha- rdtii, and the group of algae Chlamydomonas reinha- rdtii. The genetic resources for marine algae research are abundant, such as Phaeodactylum tricornutum and Cyanophora paradoxa among diatoms. However, marine algae, especially macroalgae, generally have long growth cycles, immature genetic transformation methods, and the late start of various molecular biology research in algae, making it difficult to carry out gene-editing technology in algae. CRISP Cas9 technology, a popular and simple gene-editing technology, was first applied to plant genome editing in 2013 [2]. The CRISPR/Cas9 gene-editing technology has gradually matured. It is now used in various plants, including Arabidopsis, rice, tobacco, soybean, maize, and sorghum, as a simple and convenient gene-editing method [6].

The CRISPR/Cas9 technology has been successfully applied to microalgae [7] and theoretically feasible for marine macroalgae. It has been shown that codon optimization of exogenous genes and endogenous strong promoters can improve exogenous expression vectors' efficiency in algae, with a preference for G and C due to the high GC content in the algal genome [8]. The following studies have been conducted to guide macroalgae improvement in three areas: optimization of transfer vectors, selection of genetic transformation methods, and improved editing efficiency.

2.1.4. Phaeobacticides — Potent and Selective Algae Growth Inhibitors and Reliance Symbiotic Termination Protocol

Phaeobacticides are the low-toxicity anti-algae agents which can be used in various settings, including the prevention of algal blooms. Most of the current algicides are non-specific chemicals, while phaeobacticides are optimized to target certain algae. The approaches of Clardy and Kolter can be extended to other algae resulting in a panel of phaeobacticides with different specificities. Also, phaeobacticides can be used in a combination of fungicides and bactericides, less toxic and more efficient towards resistant pathogens. Moreover, Phaeobacticides would be involved in controlling the number of our target algae, Cylindrotheca clostridium, to prevent their overgrowth.

Additionally, reliance Symbiotic Termination Protocol is the self-promoting cascade of P. gallaeciensis when detecting the pCA released from the modified Cylindrotheca closterium. The P. gallaeciensis would produce antialgal compounds, the roseobacticides, to kill the senescent algae; therefore prevent the overgrowth of algae and provide nutrition for themselves. The original mutualism includes P. gallaeciensis and Emililiania huxleyi. P. gallaeciensis attach to the surface of Emililiania huxleyi and consume DMSP provided from Emililiania huxleyi; in return, P. gallaeciensis produce growth promoter and the antibiotic tropodithietic acid for Emililiania huxleyi. However, Emililiania huxleyi does not have the ability to degrade DBP. So the genetically modified Cylindrotheca closterium will be used to replace Emililiania huxleyi and degrade DBP because DBP can be a substrate during its growth. CRISPR would modify the Cylindrotheca closterium to express the pCA production protein for the precaution of possible overgrowth. The extra pCA will be purified to eliminate Cylindrotheca closterium when they are actually found overgrowth in a specific area.

2.2. Pricing

CRISPR-edited Algae: $10 per liter
Packaging Material: $5 per liter
Transportation: $300 per purchase
$1500 per bottle commercially, or $8000 per 10km^2 through government contracts

2.3. Eco-friendly Packaging

Sodium alginate, a natural heteropolysaccharide extracted from brown algae, is often used as a matrix for packaging and delivering other active ingredients due to its unique properties. As a food ingredient, it can form calcium alginate gel films with calcium ions under specific conditions. Those films with gas-selective permeability can be used as the microalgae storage container by creating a nearly closed, self-contained environment inside. In PV-AL, we will use that property of sodium alginate to chemically react with calcium lactate solution, making our environmentally friendly packaging and avoiding the negative effect of aluminum pollution (mentioned in Identify the Root Cause about the aluminum stick on every mask).

3. Implementation Plan

3.1. Funding Sources

Our fundraising tactic contains four categories: Personal, Fundraisers/Venture Capital, Government, and Licensing. The initial apparatus budget has already been fulfilled by the East China University of Science and Technology during our CEO and CTO's summer program. However, $30,000 is still needed for the possible conference attendance and the CRISPR experimentation. The other initial funding will be covered by the personal investment from our team members. Also, we pitch to our family members, friends with a 6% annual return and expect to satisfy our initial funds within three extra investors. We will start producing day 1 when CRISPR is finished and tested and then begin reaching out for business pitching at the target companies and foundations. And our research team shall pursue various funds, including the SE'nSE Fund, a fund source to support future generations who dedicate themselves to sustainable entrepreneurs, from which we expect to allocate $4,000 of the foundation's €100,000 annual fund. Throughout the development process, we will collaborate with environmentalist groups, join the Plastic Pollution Coalition, fund educational programs and participate in related competitions to raise plasticizer awareness within the community.

3.2. Government and Publicity

To introduce our products to the governments, we will hold the product demonstrations under permission. If successful, we will form a year-long contract that promises to maintain growth of the algae below negotiated level within the area of effect.

Based on our cost analysis and revenue prediction, we will further develop our brand image by collaborating with the global environment foundations to initiate education programs and competitions. We will also promote our brand on social media, including Instagram, Twitter, YouTube, and WeChat. We plan for the process of brand promotion and digitalization to take place between the second and fourth quarters of Year 3.

3.3. Potential Consumer

Our potential consumer groups are private firms and governments; so do our marketing tactics. To the plasticizer-producing or consuming firms, we will hold a sales pitch to every leading firm in the industry and negotiate prices for the customized plan for every customer. Our targets are the major firms in the plasticizer industry, including Arkema S.A., BASF SE, Dow Chemical Company, LG CHEM Ltd., Evonik Industries AG, ExxonMobil Corporation, Eastman Chemical Company, Ineos Group, UPC GROUP, and Bluesail.

4. Response to Challenges and Root Cause

Overall, our solution is able to tackle the majority of the challenges and root causes that we have been able to identify. Most importantly, it is able to solve the issue of over-polluting the ocean and other water bodies from microplastics mainly from face masks. Moreover, it is able to provide the government with a low-risk and affordable solution. Despite not being able to focus on the issue of cognitive bias and awareness of face masks disposal, our action plan includes the marketing and publicity of our product, which will have the effect of raising awareness of the issue of plastic pollution from face masks in the ocean to both governments and individual firms. Once the governments and individual firms are able to participate in solving the issue by consuming our product and take social responsibility, the issue of raising awareness of face mask disposal will be solved. Even though the policy and action of governments cannot be easily changed, the existence of our program is able to push the government as well as the public to continuously seek improvement in the current face mask recycling system by providing our solution which follows the idea of the circular economy. Through our program, if our product is widely accepted and used by governments and firms who decide to take social responsibility, we are able to solve the challenges of saving marine animals as well as the health concerns in human society.

4.1. How our product stands out in the market

The primary differentiator is ocean adaptivity and sustainability that we are confident of becoming the only firm that provides a comprehensive plan with 100% plastic-free processing. Our SV-AL works in all marine waterbodies, outperforming Carbios, Ecopure, and Eggplant Srl which are all within controlled environments. And our solution extends beyond the scope of plasticizer degradation, unfolding endless possibilities that no box will contain.

- Culture Medium's Ingredient with Pre-cultivated Cylindrotheca Closterium
- Sodium alginate & Calcium lactate eco-friendly Reaction to make the eco-friendly package
- CRISPR

Prototype and Test

Prototype Design

The product will be a genetically modified version of the algae Cylindrotheca closterium. This is because this type of algae has been proven to live in harsh environments such as highly salty waters, meaning that it will have no problem adapting to the territories of the different oceans.

The algae will be modified using CRISPR gene editing. CRISPR is a gene modification technology that uses purely biological machinery such as proteins to cleave or insert a targeted gene. It was originally the method of bacterias to incorporate immune genes into their genome to fight off future bacteriophage attacks. This technology has been heavily tested over the last few decades on plants, such as most crops and Arabidopsis; and algal species, such as Chlamydomonas Sinhardtii and Chlamydomonas reinhardtii. CRISPR technology has matured over years of testing to become a simple and effective method of genetic engineering that is very much suitable for our purpose.

The genetic engineering that we plan to employ in our product algae will achieve three main expectations: to inject the proper machinery, the proper system, and prevent inhibiting factors of the system.

-The proper machinery:
Just as the method suggests, we will be using CRISPR to transfer the genetic material coding for the enzyme into the algae cells. The face masks are made up of mainly four materials; thus, we will incorporate the genomes of 4 enzymes that could break down each component. These enzymes will be produced after the engineering and break down available plastic in surrounding environments.

-The proper system:
The production of enzymes is not a straightforward process. It requires complex prerequisite systems, including repressors, activation sites, and transcriptional factors. We are attempting to create a rather basic and classic system that's easily manipulated and will also serve its purpose. The ideal design of this system is to create an inducible operon, similar to the lac operon in bacterias. The underlying premise is that there is an active repressor to the genes of the enzymes, and when the repressor is involved, it inhibits the process of making the enzyme. The plastic in

the ocean will serve as an autoinducer, which are molecules that bind to the repressor and deactivate it. Thus when plastic is present, the synthesis of the enzymes will be activated, and the breakdown of the plastic will be initiated. Once the amount of plastic has diminished and the autoinducer (plastic) doesn't bind to the repressor at such a high frequency, the repressor starts to become more active and the production of the enzyme will slowly cease. This allows for very versatile control of the rate of breakdown using the environmental concentration of plastic. Since the algae are using the enzymes to break down plastic and produce energy, there will be no problem of overpopulation as the algae will also die off as the level of plastic pollution diminishes. This allows for a highly sustainable cleanup that will not create additional bio-pollution hazards.

-Prevent inhibiting factors of the system:
This is the critical defining feature of our product. Although after we inserted the genetic material into the cell, the cells technically have obtained the adaptation to live off plastic. However, they might not do that. The ocean is a very nutritionally rich habitat, and many organisms can already live off of other potentially more efficient methods of obtaining energy. For example, under normal circumstances, the algae will nearly always prefer sugars and other organic molecules as a source of food rather than plastic. If we want to make the algae focus on only one of the sources of energy, which in this case is plastic, we would have to tweak or delete other pathways and genes that utilize other energy sources in the ocean, leaving the algae with only one option. One example of this is to impact the ability of the algae to use sugars. Algae is a photosynthetic prokaryotic organism, meaning that its most preferred method of obtaining energy is to use sunlight to produce sugars, which is obviously going to be a major hindrance to the success of our product. However, we could, for example, make mutations in the proteins involved in glycolysis (the process of splitting sugars, the most crucial way of deriving energy from sugars in photosynthetic prokaryotes) by using CRISPR technology to delete certain nucleotides, disrupting the function/efficiency of the proteins involved in glycolysis, causing inhibition to glycolysis, and make plastic catabolism the more preferred option. Make these kinds of modifications on some other major energy-producing pathways and the plastic breakdown pathway will soon become a very appealing option for obtaining energy for the algae, creating a population controlling method of the algae that depends almost solely on the plastic concentration, further reinforcing the sustainability and safety of our product.

- CRISPR genetic engineering mechanism
- Inducible Operon mechanism

Feedbacks learnt from users

Currently, governments in several countries, like Australia and Columbia, have already taken some actions to deal with plastic pollutions. In this section, we compare the enzyme solution with two typical existing solutions to show the reason why consumers would choose this new generation of solution.
Firstly, we mentioned in the previous about the inspector program. It sets up walls to collect floating plastic on rivers to prevent it from draining into the sea. Compared to the inspector, our enzyme solution has some advantages and consumers are more likely to choose this procedure. First, the enzyme solution can decompose a wider range and much more amount of plastic in the masks. Since it can move in the wide area of oceans, it can automatically find and degrade pollution, which makes it more apt to deal with the global problems we are facing. Because of that, it is more economical and convenient when consumers apply it to a large scale of sea as well. This is an essential point when we want more corporates and governments to apply this procedure.
Besides, the second pro is that it requires less labor and money to maintain its function. Because of its ability to control its population, enzyme doesn’t need to be cared often. Nevertheless, regular cleaning to remove the masks collected and checking for the elements are necessary for the inspector, making it more expensive to use in the long run.
Other than the inspector, the PEM is also used by some governments and organizations to burn wastes, especially plastic in the masks. It is an innovative way to finish the pollution caused by plastic since it changes it into usable gases and even clean energy. However, enzymes still have many advantages over them. For example, the PEM is not technically mature now. Though the theory is already developed, more effort is required to develop this technology until it is applied in the market. As for the enzyme, both the principles and the experiments are very practical and mature, making it ready to deal with more diverse conditions and have good effects, which is an important point for users to consider.
Additionally, enzymes are more mobile than the PEM solution. Since large scale PEM machines are needed to clean up the large amount of masks, the mobility of them are big problems. After a certain area’s pollution is diminished, it takes much time, capital, and workforce to transmit it to other locations. But enzyme doesn’t need that process. Instead, it moves across the ocean by itself and chasing the lanes of pollution as well. So it is more feasible for consumers when they consider these factors.

In our survey part, we made some questionnaires to investigate users' preferences and their feedback on our program. Since people live in coastal or riverside regions are the potential groups who can recognize changes in marine pollution after applying our solution, both qualitative and quantitative feedback from them is necessary to find out the effectiveness of the solution.

1.1 Both Quantitative and Qualitative feedback learned from users

Questions in the (online) Questionnaires are listed below:

1. Will it solves the problem?
a) Absolutely Yes.
b) It might work.
c) It might not work.
d) It does not help at all.

2. Will you encourage this kind of solution to be used?
a) Yes
b) Afraid of some its unknown consequence, so no

3. Will you accept this kind of solution?
a) It seems to be a great deal.
b) I don't this solution will help with the problem
c) I refuse to use this kind of solution before it has been widely proved useful.

4. Do you think this is a better, worse or no significant difference compared with other solutions such as substituting materials of masks or increasing social awareness of this problem?
a) Better
b) No difference
c) Worse (If someone chooses worse, they will jump to another question to select the best solution they think.)

5. If worse, what following solution do you think is better than the previous one.
a) Using other materials such as bamboo fiber or cotton.
b) Plasma Enhanced Melter (The PEM is a kind of device that uses plasma to process, recycle and reuse most types of waste)
c) Using a specific enzyme to degrade the plastic (PETase, (polyethylene terephthalate-ase) which is a hydrolase naturally occurring in both the bacteria Ideonella sakaiensis and the fungi Pestalotiopsis microspora.)
d) Non-thermal plasma is a category of plasma technologies combined with printed electronics to safely reuse single-use personal protective equipment (Masks).
e) Recycle the masks by separating them into the different parts and let each part with different materials experience some purify process; after that, using on constructing other plastic products.

6. What's your primary impression about the mentioned solution? (Optional)
(Fill out the blank)

1.2 Scientific and Qualitative feedback from scientists and researchers
Apart from coastal or riverside residents as stakeholders, scientific data is also

significant to determine to what extent our solution effectively alleviates marine pollution. Water Quality sampling before and after implementing the solution is needed; Monthly, Seasonally or annual statistics of the number of plastics in the ocean is also essential. Additionally, data about the marine lives being influenced by plastic pollution such as fishes, dolphins or whales before and after applying algae (who might accidentally consume plastics or microplastics) needs to be collected.

Improvement for next iteration

1. The uncertainty of the number adjusting ability
In our current model, the number of enzymes will adjust automatically according to the amount of plastic in a particular area. However, this is only theoretical, which means we haven't proved that by our experiment. Although the theory is very plausible and reasonable, we still need to exam it in our future generation.
So, our solution is to set up a series of examinations. First, we test the growth rate and the number after it's stable in the lab to have a basic conclusion. Then, we test it in a small area of water, such as an isolated lake, to further test the reliability in larger water bodies. After that, we put some predators or chemical substances into the water body to reduce the number of algae. At last, we will test in a certain area of the ocean and supervise the number of algae constantly and closely. We will monitor it using some special equipment like isotope detectors to make sure we can handle the number and scale of the algae. If there is anything wrong with any of the exam processes, we block the connection between the test area and other water areas.

2. The impact on ocean animals.
This alga focuses only on the resolution of plastic pollution; thus, it hasn't be considered much about the impact of aquatic animals. For instance, some fish might eat this alga, but some substances might be harmful to the fish, causing their deaths. Besides, the alga has some chance to compete with the existing plants in the ocean for some resources like oxygen or living spaces, so it can shrink others' number of living possibilities.
We will test what would happen if we put some marine organisms with the alga we produced. For detail, we will put some fish, crabs, and some aquatic plants into a small water area with the algae and check its consequences on the living environment. Then, when we extend our testing area, just like the procedure we mentioned in the improvement of number, we also supervise the influence with more diverse marine animals and decide the further adjustments. We will change the growth rates, the living requirement, and the resources needed of the alga we developed, and remove some fatal components so that animals won't be affected. As a result, we will adjust the composition of the alga so that it can be harmful and

even become a suitable food supply for some marine organisms.

3. The influence of human constructions.

There are many artificial buildings in or beside the ocean, such as bridges and fishing gears. Since the alga will decompose all the plastic in the mask, we need to test its influence on other artificial structures. We are not sure whether it will damage some parts of the bridges or some plastic substances of the ship, so we decide to improve the specialized ability of the alga.

The alga, after adjustment, will focus better on the plastic of the masks. Because the material of the bridges and the masks are different, the current alga we use can only solve the mask's plastic. But our group will still test whether other types of plastic, metal, and concrete. Thus we can improve the focus of the alga so that the cost of human society can be minimized.

Team Credits

Zhuohui Lyu (Benson) is responsible for deciding the overall topic, organizing timelines and make corresponding plans, writing summary, generate solutions, feedback from users and conclusion parts. He is also compiling everyone's writing into this final work. Additionally, Zhuohui is a very well-organized person that informs related information to group members on time, that our project could not be well-accomplished without him.

Yirong Geng (Erica) is responsible for writing identify the challenges, root cause and criteria, generate solutions and evaluate the solutions parts. At the same time, she is the leader of this project on a temporary basis since Zhuohui has a problem with Covid quarantine during the first half of August. She is in charge of organizing meetings and distributing works at that time. The punctuality in meeting the 1st draft deadline is credited to her.

Emily Tian is responsible for writing identify the challenges and root cause, generate solutions, and contributing the most in making the action plan part. She was also in charge of leading the improvements section. The main solution of the project for us to tackle the marine pollution caused by the overuse of facemasks is raised by Emily, that the project cannot progress so well without her.

Zhiyuan Shi (Tony) is responsible for writing generate solutions, single handedly producing the prototype design and made improvement for next iteration. He makes a lot of improvement on our main solution on the basis of Emily's idea by utilising biological and chemical knowledge, and that the completion of the action plan is also partly credited to him.

Shixuan Yuan (Steven) is responsible for “PEM” and “Inspector” parts in generate solution section and complete the evaluations of these two solutions. Besides, he works on improvement for next iteration and users feedback sections as well.

GuanYuan Zheng (Andrews) is responsible for writing feedbacks learnt from users. Specifically, the questionnaires in feedbacks learnt from users part is written by him, and he also raises a bunch of new ideas for us to explore and accomplish the project.

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Onsite Conference File

Judge Comments

" The team has done an excellent job in researching and scoping the problem – also, congrats on addressing and exploring a very timely problem. I suggest that the team be mindful of properly citing the sources that are being used in the report, it not only helps strengthen the quality of your work, it provides a handy tool for anyone else following your work to dig and develop your ideas further. I note that there is a list of references in the end, but it would be helpful to link them back to appropriate references within the body of the text. Kudos on identifying and citing Dr Chelsea's work, who is one the preeminent researchers on human health from microplastics in the marine ecosystem.

In reference to the bacterial enzymatic approach, I would also suggest that the introduction of bacteria into large ecosystems such as the ocean is not a "solution that creates theoretically no additional drawbacks". I do applaud the amount of research that has gone into identifying geoengineering options as a solution. It was unclear to me how the proposed solution would generate profit (6% return to investors listed). I also noticed that there seems to be a mismatch between the solutions proposed and the solutions evaluated? I would also suggest that the team explore how upstream solutions (behaviour change, product design, capture before release into waterways etc.) can play a role in the solution.

I find this proposal to be incredibly ambitious, perhaps at a scale outside the scope of what is achievable within the current context of this competition. I applaud the team for thinking big and wish them well in pursuing this and similar efforts to better the environment we share.

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