Bio-Plastic Consumer Outreach in Costa Rica

Isaac Frederique

James Vo

Andrew Voronin

Bio-Plastic Consumer Outreach in Costa Rica

An Interactive Qualifying Project report submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements of the Degree of Bachelor of Science

Submitted by:
Isaac Frederique
James Vo
Andrew Voronin

Submitted to:

Cristina Sanchez
The MarViva Foundation

Professor Ulrike Brisson
Professor Creighton Peet
Worcester Polytechnic Institute

Date Submitted:
04 March 2022

Abstract

The goal of this project was to determine the prevalent misconceptions pertaining to the disposal of plastic products to reduce the plastic pollution in Costa Rica. Through literature review, interviews, and a survey, working alongside the MarViva Foundation we developed a deliverable for both the public sector, as well as commercial establishments that is designed to educate both consumers and producers on how to properly dispose of the different types of plastics.

Acknowledgements

We are grateful to have been given this opportunity during the Covid-19 pandemic to travel to Costa Rica to complete our project addressing the issues of plastic pollution, even if it was only for 4 weeks. We are also appreciative of the following groups and individuals that gave us their continued guidance and utmost support during our project. Without them, this project would not have been possible, so thank you for lending us a helping hand.

First, we would like to thank our sponsor organization, the MarViva Foundation, for an unforgettable project experience. We appreciate all your help for providing us with opportunities to conduct research, interviews, and surveys with commercial establishments in Costa Rica. In the MarViva Foundation specifically, we would like to give thanks to Cristina Sanchez for being our sponsor contact with her mentorship and guidance throughout the project, Alberto Quesada for organizing the interviews with the commercial establishments in Nosara partnered with the MarViva Foundation and for his expertise relating to plastics, and Mariano Barrantes for his time assisting us in the beginning of our project.

Secondly, we would like to give appreciation to the representatives of the four commercial establishments in Nosara partnered with the MarViva Foundation: Celajes, Hotel Harmony, Hotel Olas Verdes, and Pueblo Dorado Surf Hotel for taking time out of their busy schedules for productive interviews with us, providing us with useful information to use in our project.

Next, we would like to express gratitude towards the faculty of Worcester Polytechnic Institute for supporting the Interactive Qualifying Project. We would like to thank our advisors Ulrike Brisson, James Chiarelli, and Creighton Peet for their guidance throughout both B and C

terms, providing us with feedback to develop and complete our project. Additional gratitude to Melissa Belz for coordinating projects for students each year and Lori Ostapowicz-Critz for her assistance with writing this report.

Finally, we appreciate the staff at the Tairona Hotel for incredible hospitality during the four weeks in Costa Rica. And a big thank you to our fellow San José, Costa Rica groups for creating unforgettable bonds and memories during this once in a lifetime experience.

Authorship

Note: Every chapter and every section was reviewed and edited by all.

Abstract – James Vo
Acknowledgement – James Vo
Executive Summary – James Vo
1.0 Introduction – James Vo
2.0 Background – James Vo
- 2.1 Plastic & Pollution – Isaac Frederique
  - 2.1.1 Global Impact of Plastics – James Vo
  - 2.1.2 Single-Use Plastics – Isaac Frederique
  - 2.1.3 Microplastics – Isaac Frederique
  - 2.1.4 Pollution Effects – Isaac Frederique
- 2.2 Comparing Recycling and Composting – Isaac Frederique
  - 2.2.1 Recycling – Isaac Frederique
  - 2.2.2 Composting – Isaac Frederique
- 2.3 Bioplastics & Biodegradability – Andrew Voronin
  - 2.3.1 Bioplastics – Andrew Voronin
  - 2.3.2 Biodegradability – Andrew Voronin
  - 2.3.3 Misconceptions – Isaac Frederique
- 2.4 Classifications and Certifications – Isaac Frederique
  - 2.4.1 BPA-Free Labeling – Isaac Frederique
  - 2.4.2 Plastic Numbers 1 through 7 – Isaac Frederique
  - 2.4.3 BPI Certification Program – Andrew Voronin
- 2.5 Strategies to Reduce Plastic Pollution – Andrew Voronin
  - 2.5.1 Oxo-Plastics – Isaac Frederique
  - 2.5.2 PETase – Andrew Voronin
  - 2.5.3 Recycling Methods in Costa Rica – Isaac Frederique
  - 2.5.4 Ecoins – Andrew Voronin
  - 2.5.5 Effects of Covid-19 – Andrew Voronin
- 2.6 MarViva Foundation – Andrew Voronin
  - 2.6.1 The #ChaoPlasticoDesechable Campaign – Andrew Voronin
  - 2.6.2 Knowledge Discrepancy – Andrew Voronin

3.0 Methodology – James Vo
- 3.1 Identifying Certifications and Processing Methods of Common Plastics – James Vo
- 3.2 Supermarket Product Identification – Andrew Voronin
- 3.3 Surveying the Public – James Vo
- 3.4 Interviewing Commercial Establishments – James Vo
- 3.5 Training Representatives – James Vo
- 3.6 Methods Summary – James Vo

4.0 Results and Analysis – Andrew Voronin
- 4.1 Product Certifications Analysis - Isaac Frederique
- 4.2 Plastic Products versus Other Alternatives – Isaac Frederique

Table of Contents

Table of Figures

Table of Tables

Executive Summary

Perhaps one of the more major environmental concerns that countries face is plastic pollution. Plastic pollution is described to be the accumulation of plastic objects and particles that harm the Earth's environment, such as ecosystems and wildlife (Moore, 2022). Hence, the continuous use of plastic products, as well as not properly disposing them, predominantly contributes to plastic pollution. Costa Rica is one of the nations that face similar problems with plastic pollution, due to the misconceptions of how to properly dispose of their plastics. Despite the efforts from President Carlos Alvarado Quesada and the Costa Rican government to eliminate all single-use plastics by the year 2021, there has been minimum support from the consumers of the public sector and the producers of the private sector to reduce plastic pollution (Lindwall, 2020).

It is estimated that 550 tons of plastics are discarded in Costa Rica daily, with 80% ending up in the waters of the Caribbean Sea and the Pacific Ocean and 11% in landfills (Alvarado, 2018). With provided education in the proper disposal of plastic products, common misconceptions pertaining to improper disposal could be eliminated to decrease the amount of plastic waste. Thus, there is a need bridge the gap between the consumers of the public sector and the producers of the private sector to combat against the lack of knowledge of the different types of plastics and proper ways for the disposal of each type to reduce plastic waste in Costa Rica.

The goal of this project was to contribute to the development of a strategic plan through a public outreach campaign supported by the MarViva Foundation that would help educate the public sector to reduce plastic pollution across Costa Rica. To achieve the project goal, the team developed the following set of five objectives. Through extensive research to start our study, the

team gathered information pertaining to various plastic packaging and labeling certifications on common plastic products by visiting multiple supermarkets in Costa Rica to determine if there were certifications that supported the companies. Next, surveying the consumers of the public sector of Costa Rica in-person, as well as through MarViva's social media, helped to distinguish the common misconceptions of the disposal of the various types of plastics. Then, conducting interviews with the representatives of the four commercial establishments partnered with the MarViva Foundation, helped to reveal the opinions of, and the attitudes towards increasing public awareness on proper disposal methods to reduce plastic pollution. With the information gathered through research, product analysis, surveys, and interviews, a deliverable was developed for MarViva to inform the public and private sectors of these plastics.

Through consumer surveys, a bevy of information was acquired relating to the common misconceptions of conventional and bioplastics, proving they exist among the Costa Rica public. For example, the common misconception pertaining to the expensiveness and price difference of more environmentally friendly options compared to conventional plastics. However, the product analysis supported that both were similar in price and should not be an issue when deciding between conventional plastic products versus biodegradable and/or compostable plastic products. These surveys helped directly identify specific misconceptions that the Costa Rican public had about various types of plastics, bringing to light the lack of knowledge within the population when dealing with the disposal of compostable plastics and when recognizing similarities between conventional plastics and bioplastics.

From the commercial establishment interviews, it was revealed that all four locations in Nosara, Costa Rica were environmentally conscious. These four commercial establishments partnered with MarViva adopted environmentally friendly and sustainability practices to reduce

plastic pollution. For example, providing customers and guests with alternatives to plastic products, such as bamboo or metal straws instead of plastic or paper straws, glass or wooden cups instead of plastic or Styrofoam cups, wooden tableware and utensils instead of plastic table and utensils, etc. Through conducting these interviews with the representatives over Zoom, they also believed the reason Costa Rica lacks the knowledge pertaining to plastics is because there is a lack of education for the newer generations. Therefore, education and legislative support are necessary to limit those common misconceptions to reduce plastic pollution. With all the gathered information, we developed a deliverable with infographics for MarViva to hand out to representatives of partnered commercial establishments, as well as to the general public.

After gathering the information, our group concluded based on our research that the lack of education and minimal to no legislative support led to the common misconceptions about the various plastics and proper disposal methods, the unclear labeling for eco-friendly products, and the need for more recycling efforts, ultimately, contribute to the plastic pollution in Costa Rica. We recommended the following methods to help MarViva and the Costa Rican community to successfully implement more environmentally safe practices. Firstly, education and widespread awareness to new generations was found to be a key aspect for the reduction of plastic pollution. Another recommendation we had for MarViva was to advocate for research and development for materials with similar properties to plastics that are not as harmful to the environment. Additionally, we recommend that MarViva pushes for a BPA-free labeling update to make identifying the disposal method for plastic simpler. Finally, we recommend incentivizing plastic products to attract the public to follow sustainable waste disposal methods. At the conclusion of this project, our group believes that there needs to be more efforts from organizations like the

MarViva Foundation to address these plastic pollution issues to support the environment in Costa Rica.

1.0 Introduction

When thinking about environmental disasters throughout the world, what first comes to mind? Perhaps earthquakes, hurricanes, tornados, or volcanic eruptions, but what about plastic pollution? The ongoing use of plastic products worldwide contributes to plastic pollution, causing negative effects on the earth's ecosystems, wildlife, and humans.

Countries and nations from across the globe have been working to minimize or eliminate plastic waste in the Earth's environments, including Costa Rica. According to the United Nations Development Program (UNDP), Costa Rica was the largest plastic importer in all Central America (Alvarado, 2018). Proper disposal of plastics could decrease the amount of plastic waste. Common misconceptions have led to improper disposal of many plastic products. These misconceptions stem from understanding about plastics' biodegradability, composability, recyclability and even how they are labeled (Goel et al, 2021). It is estimated that 550 tons of plastics are discarded in Costa Rica daily, with 80% ending up in the waters of the Caribbean Sea or the Pacific Ocean and 11% in landfills (Alvarado, 2018). The underlying problem is that most individuals assume that recyclable plastic objects are biodegradable, so the methods of how they should be properly disposed of are often overlooked and/or misunderstood.

Along with other countries, Costa Rica is taking strides in the right direction with research on reducing the amount of plastic waste produced and utilized daily. In some countries like the United States of America, for example, companies and municipalities offer incentives at commercial establishments, including grocery stores and department stores, to reduce plastic waste. The retail companies like Shaw's, Wegmans, or Stop & Shop incentivize consumers to bring their own grocery bags or by distributing brown paper bags instead of plastic bags. While

Costa Rica has attempted incentivizing recycling by creating a virtual currency called Ecolones, or Ecoins, it has not been unsuccessful so far (Earth University, 2018).

President Carlos Alvarado Quesada of Costa Rica had announced his goal to eliminate all single-use plastics and fossil fuels by the year 2021, making it the first country in the world to do so (Lindwall, 2020). Despite these efforts, there has been minimum to no support from the government with these local efforts, due to the lack of knowledge of the various types of plastics and proper ways for the disposal of each type. Perhaps the predominant problem with plastic pollution in Costa Rica is the lack of facilities to break-down and compost plastic objects. In 2015, the MarViva Foundation launched their #ChaoPlasticoDesechable campaign that aimed to combat plastic pollution in marine ecosystems through the banning of using single-use plastics and urging for improved waste management systems across Costa Rica. MarViva wants to expand their campaign to more businesses and open up opportunities for more partnerships in order to reach the end goal of producing zero plastic waste.

The goal of this project was to assist MarViva in increasing consumer and producer knowledge on the processing needs to properly dispose of and/or recycle the different types of plastics. Thus, we identified certifications on plastic products in the Costa Rican supermarkets to generate an easy-to-understand deliverable with information on each type of international plastic certification. Another objective was to raise awareness among the public pertaining to the reduction of plastic pollution, as well as among commercial establishment partners. To do so, we conducted an in-person survey to consumers outside of the Costa Rican supermarkets, as well as distributed the survey on MarViva's social media. Aside from the surveys, we interviewed representatives of four commercial establishments partnered with the MarViva Foundation about their use of plastic products. From all the information and research gathered, we concluded that

the lack of education in Costa Rica pertaining to properly disposing of plastic products leads to these misconceptions, ultimately resulting in plastic pollution. Due to the inability of most plastics to break down easily, as well as the lack of adequate plastic recycling, plastic pollution will prove to be an ever-growing issue for decades to come. The underlying problem is that most individuals assume that plastics and bioplastics are biodegradable or compostable and can be sent to landfills to degrade, so the methods of how they are disposed of are often overlooked and/or misunderstood.

2.0 Background

To begin a discussion about plastics and plastic pollution, in this chapter we explain what the different types of plastics are, how each is composed, as well as the process needed to break-down, biodegrade, and compost each type of plastic. Another topic we discuss has to do with describing what is happening in Costa Rica, as well as the rest of the world, pertaining to the use of plastics and the pollution they cause. Along with that, we discuss how Costa Rica and the rest of the world have attempted to reduce plastic pollution through certifications, incentives, and recycling. Finally, we discuss the efforts the MarViva Foundation has made to reduce plastic waste in Costa Rica.

2.1 Plastic and Pollution

Plastics account for a large portion the world's ever-growing pollution problem. Such an issue could largely be reduced if all plastics suddenly became compostable or biodegradable, but unfortunately this is not the case. Studies show that there is an estimated 150 million tons of plastic debris in our oceans, with approximately 8 million tons of plastic being added each year (Ocean Conservancy, 2018). The massive amounts of plastic in the oceans have major impacts on marine ecosystems. Fish and other marine animals are directly impacted by plastic debris. In the North Pacific alone, fish can consume up to 24,000 tons of plastic each year, which can lead to internal injuries and death (The Center for Biological Diversity, 2021). The plastic debris can carry around toxins and contribute to bioaccumulation (IUCN, 2021). Improperly disposing of plastics leads to the accumulation of waste in landfills and contributes to the pollution of the marine environment. Many recyclable and compostable plastics must be processed correctly to minimize waste. This is mainly an issue with single-use plastics as they may not be properly

labeled or are made from materials that are non-recyclable. These same plastic materials account for the largest percentage of ocean debris.

2.1.1 Global Impact of Plastics

Around the world, plastic waste of consumers ends up in the oceans and pollutes marine habitats everywhere; it is estimated that there will be more plastic than fish in the ocean by 2050 (As You Sow, 2022). Natural ecosystems were not designed to handle all the pollution in the oceans. Fish eat plastic, which then becomes the fish on our dinner plates. Sea birds choke on trash they find floating in the water, and seals suffocate under plastic bags. Sea turtles eat plastic, which takes up space in their stomach so that they do not feel the need to eat anything else, and inevitably starve themselves to death due to a lack of nutrients. Humans have even polluted the deepest parts of the oceans, places where we seldom travel. Expeditions to the ocean seafloor have uncovered fishing nets, buoys, and tons of plastic, harming ecosystems that we didn't even know existed.

2.1.2 Single Use Plastics

We often prioritize convenience over quality and durability. Single-use plastics fit into this niche perfectly. Thirty-three percent of plastics are only used one time before they are disposed of (Sitterson at el, 2017). The main issue is most of this plastic is non-biodegradable, and it will take hundreds of years to decay. These plastics are typically used for dining, packaging, and medical purposes (Lindwall, 2020). Many single-use plastics have harmful additives that can also leach into the water. Some of the contents in plastics are known endocrine disruptors that can lead to several health complications. The chemical makeup and additives

account for most of the major problems due to plastics. The chain of synthetic polymers that most plastics are composed of will break down mechanically into smaller pieces but will struggle to be degraded and chemically broken down beyond these microplastic pieces. The breakdown of plastic into microplastics only further adds to the numerous issues already caused by plastic pollution.

2.1.3 Microplastics

Microplastics are classified as fragments smaller than 5mm in diameter. Fragments smaller than 100nm are described as nano plastics (IUCN, 2021). Microplastics are the focus for many research groups across the world since their effects are not completely known. We know that these microplastics contribute to bioaccumulation, but they function slightly differently than the toxins that typically bioaccumulate. It is known that the micro- and nano-plastics in the sea water accumulate toxins on their surface. After entering an organism, the plastics themselves can accumulate toxins from within the body during digestion and carry some toxins out when it is excreted (Abbing, 2019). The plastics can add and remove accumulating toxins making the mechanisms and effects extremely complex and difficult to study. Bioaccumulation is an issue in which microplastics play a significant role. The effects of these plastic particles on the marine ecosystem also translate to problems with our everyday living.

2.1.4 Pollution Effects

Plastic pollution in the ocean is causing over 1 million fish to perish per year (Sea Turtle Conservancy, 2021). The floating plastic debris in our oceans is often mistaken as food by fish or other marine wildlife. These plastics are not biodegradable, let alone digestible, so oftentimes the

animals die. Fish are directly harmed, but food quality and safety are also indirectly affected. Bioaccumulation is the buildup of toxins, like heavy metals or microplastics, in an organism. Biomagnification is the increase in concentration of toxins as nutrients move through the food chain. The toxins, or plastics in this case, are ingested at a faster rate than they can be processed and excreted leading to a buildup of physical mass in the digestive tract. Microplastics present a greater issue when dealing with biomagnification, since micro- and nano-plastics can also accumulate toxins and bring them into the body of organisms. The toxins will remain as nutrients travel up the food chain, eventually affecting the food supply we rely on. A study found that a quarter of fish markets in California were selling fish containing plastics in the digestive tract. It is also estimated that over 60% of all seabirds have eaten pieces of plastic (The Center for Biological Diversity, 2021). The effects of ocean pollution are not exclusive to the ocean; failing to protect the marine environment has detrimental effects on most life on earth. With the current rate of plastic consumption, the plastics in the ocean are on schedule to outweigh all fish by 2050. Plastic pollution is not only a problem for organisms directly. Many plastics are made from fossil fuels, the process of mining fossil fuels contributes greatly to greenhouse gas emissions. Plastics that are sent to landfills will have a lack of access to oxygen when breaking down and will release methane, a major greenhouse gas. Plastics contribute to planet warming greenhouse gas emissions at all stages, from manufacturing to degradation (Lindwall, 2020). Despite this overwhelmingly negative information, the use of plastic products and the lack of sufficient recycling causes an ever-growing problem of plastic pollution.

2.2 Comparing Recycling and Composting

Recycling and composting are both methods to minimize waste, but there is a significant difference between the two. The chemical properties of materials will determine if the plastic should be recycled or composted (Seaman, 2012). Plastic polymers like PHA or PLA should be composted since they can be broken down by microorganisms, whereas other plastics like PET should be cut up and recycled into a new PET material. In both cases, the methods used to dispose of these plastics will help decrease the amount of plastic waste that contributes to ocean pollution.

2.2.1 Recycling

Recycled plastic materials are collected, cut up, melted, and formed into a new product. The process can be split into two sub-categories, post-consumer and postindustrial (Ecoenclose, 2018). Post-consumer recycling involves the item being collected and stored by a reclaimer after use. Postindustrial recycling is the collection and reuse of the scraps that were produced during manufacturing. There is also a difference between recycling and downcycling. Both options maintain the chemical structure of the plastic, but recycling will convert the material back into the item that it was previously. Downcycling will change the item into a new product. Recycling can conserve natural resources, reduce greenhouse gas emissions, and minimize waste in landfills by re-using plastic materials. Not all plastics can be recycled, but there are other methods of disposal for particular types of plastic.

2.2.2 Composting

Composting is the more environmentally friendly option for keeping plastics out of landfills and industrial processing facilities, but there is not a large selection of compostable plastics. Plastics like PHA or PLA are composted and can be broken down into soil material under specific conditions with the help of microorganisms. These conditions depend on the product but typically require a range of temperatures, pH, and sunlight. The final product from composting can be used for fertilization as it produces biomass with nutrients and a lot of microorganisms (Ecoenclose, 2018). Composting is one of the more beneficial ways to get rid of waste since the product can be used for agriculture. The "natural" fertilizer can be used and will decrease the use of chemical fertilizers that can contribute to run off and lead to further environmental issues. Like recycling, composting would also decrease the amount of plastic put into landfills. Compostable plastics will not be recyclable as they are designed to break down into water, carbon dioxide, and biomass.

2.3 Bioplastics & Biodegradability

It is often overlooked, but conventional plastics are made from fossil fuels and are a product of the oil and gas industry. Traditionally, these plastics come from petroleum byproducts that are pumped via oil rigs (Lehigh University, 2021). The reason behind these plastics being so commonly used is that they are durable and cheap to produce and manufacture. However, it is these plastics that contribute the most to the world's global plastic pollution problem. Their inability to break down completely creates risks for the environment and for wildlife. In an effort to reduce plastic pollution, bioplastics are gaining interest in the industry for their reduced use of fossil fuel resources and their faster decomposition time. In this section we will discuss the growing industry of bioplastics and how they degrade over time.

2.3.1 Bioplastics

The concept of recycling and the push for circular economies have put the handling of plastics as a major priority for communities around the world. Bioplastics are plastic materials that are produced from renewable sources, more specifically biomass (Künkel et al, 2016). Examples of renewable sources that are often used to produce bioplastics can include recycled food waste, straw, and sawdust. There are even some bioplastics that are produced via natural polymers such as polysaccharides, proteins, sugars, and lipids (Künkel et al, 2016). These plastics provide an eco-friendlier alternative to conventional fossil fuel plastic. A study done out of Columbia University, found that switching from fossil fuel plastics to corn-based bioplastic could cut the U.S. greenhouse gas emissions by 25 percent (Posen et al, 2017). Furthermore, if fossil fuel plastics began production using renewable energy, then greenhouse gas emissions would drop by 50-75 percent. Bioplastics are the future, but at what cost? The consumer's wallet. Certain bioplastics such as polylactic acid, PLA, may cost up to 20-50 percent more to produce than traditional plastic because of the complex process required to convert the renewable biomass into the building blocks for PLA (Künkel et al, 2016). This could be seen as a deterrent for consumers who, despite wanting to be eco-friendly, may not want to invest in a more expensive plastic alternative. However, because plastic pollution is such a problem, investing in specific bioplastics may be an acceptable option to keep the environment around us as clean as possible. It should still be noted that not all bioplastics are environmentally friendly. They may be a more sustainable option, but the degradation of most bioplastics still has a similar timeline to conventional plastics and will take hundreds of years to completely degrade.

2.3.2 Biodegradability

Biodegradation can be classified as the process a material undergoes to decompose through interactions with biological elements (Lallement et al, 2021). Therefore, biodegradability tells us how well a product decomposes over a period. To understand this better, take fossil fuel: plastics, for example, are pumped by oil rigs out of the ground emitting harmful gases into the air. Petroleum is a toxic crude oil that does not biologically and chemically breakdown over time without human intervention (Lehigh University, 2021. Therefore, oil spills are severely damaging numerous ecosystems. For reasons like this, the plastics industry began looking for alternatives, such as bioplastics, a plastic that can be biodegraded and recirculated back into the environment, on some occasions. Biodegradability is dependent on the chemical composition and each plastic has a different chemical makeup, hence the various names of plastics (Künkel et al, 2016). The problem that arises from this is that not all bioplastics are biodegradable. A bioplastic can be made from renewable sources and at the same time be incapable of physically and chemically breaking down completely in the soil, if composted. Therefore, standards and certifications have been put in place to test the feasibility and biodegradability of plastics, so consumers can understand the products they are working with.

2.3.3 Misconceptions

As the global plastic pollution problem is recognized, efforts around the world have been made to limit the problem, ranging from recycling to development of new plastic material that will be much less harmful to the environment. The introductions of OXO-plastics and bioplastics are just a few examples of this (Abdelmoez et al., 2021). These products have the possibility to begin minimizing plastic pollution, but they are only effective if the general public understands

the true nature of the newly introduced products. The myths and misconceptions behind the proper disposal of plastic products reduce the viability of using plastics that can red4.2uce pollution. Understanding the difference between biodegradable and compostable products is important. Both options require the materials to be completely broken down into carbon dioxide, water, and biomass, but compostable products must also follow a time constraint and cannot leave toxic residues (Goel et al, 2021). To account for this, certifications have been put in place to properly identify the disposal methods. Some companies still advertise and sell products that are labeled biodegradable or compostable without meeting the international standard, which leads to consumers purchasing incorrectly labeled plastics. Bioplastics have their own set of misconceptions that have developed from the misleading name. Although the name may make it seem that bioplastics are environmentally friendly, many of them are not and still require the correct processing to be recycled or properly disposed of. The term bioplastic comes from the idea that plastics are plant-based but fails to speak to the biodegradability of the products because not all bioplastics are biodegradable. Producers and consumers must both be responsible when it comes to the disposal of plastics since the misconceptions stem from both groups. International certifications must be followed by the producers to allow the consumer to make educated purchases when buying items made from or packaged in plastic. The consumers must be knowledgeable about the different terminologies used for these products for the plastics to be disposed of correctly.

2.4 Classifications & Certifications

To distinguish among products on the market, proper characterization is crucial in producing and distributing a trustworthy product to the public. For this reason, various

organizations take part in the labeling, classification, and certification of products to ensure that businesses are selling products the public can trust. In the following section we will discuss issues with BPA labeling, the classification of plastics one through seven, and a certification program to validate the biodegradability of a plastic.

2.4.1 BPA-Free labeling

BPA stands for bisphenol A, a chemical that has been used in plastics since the 1950s. Many plastics contain this chemical, and it is a known endocrine disruptor, and when food or drinks are stored in plastics containing BPA, the chemical can passively leach out of the plastic into the contents within the container and can be ingested (Rubin, 2011). The chemical is used as a building block for polycarbonate plastic, but the biological complications caused by this chemical have led to a general separation between BPA containing products and BPA free products. The effects of BPA have been known for years, but action was not taken until the early 2000's when industries began to reduce the use of the chemical. Around 2010 the decision was made to omit the use of BPA in any baby bottle like containers due to the health effects. A classification system was put in place to identify and separate BPA-free plastics from plastics that contain BPA (Center for Food Safety and Applied Nutrition, 2014). The system uses a marking on plastic materials that have three arrows shaped into a triangle containing a number one though seven. Numbers one through six are all considered to be BPA-free, whereas plastics labeled as seven can contain BPA or do not fit into the first six classifications (AHMC Anaheim Regional Medical Center, 2016). There is a massive misconception that the BPA-free symbol on plastics indicates that the product is recyclable, but the recyclability of the plastic is completely

unrelated to the BPA-free classifications.

2.4.2 Plastic Numbers 1 through 7

The BPA-Free plastic categorization uses seven classifications, typically based on the molecular composition of the polymer. Plastics labeled one, two, four, and five are considered the safest of the seven categories (Seaman, 2012). Plastic number one is polyethylene terephthalate or PET, and its intended use is to make single-use plastics like water bottles. The material is hard to decontaminate and may leach carcinogens. PET should only be recycled. The chemical composition does not allow the material to be compostable or biodegradable. Plastic number two is high-density polyethylene (HDPE) and is typically used to make things like milk jugs and plastic picnic tables. HDPE is considered one of the safest forms of plastic, and it is the most recycled. The properties of the material make the plastic useful for objects that require durability and weather resistance. HDPE should be recycled but not composted since the material will not be broken down by sunlight. Plastic number four is low-density polyethylene, which is typically used to make plastic bags. Like HDPE, LDPE is considered one of the safest plastics, and it is less toxic than other plastics. LDPE is not typically recycled, but the recycling programs are moving toward accepting this material so it can be melted and recycled into things like plastic lumber. This material is not compostable, but it is recyclable. The plastic simply is not accepted by recycling programs due to thin sheets and bags jamming the equipment. Plastic number five is Polypropylene, or PP, and it is a tough, lightweight plastic with good heat resistant qualities. Polypropylene is typically used to make containers and straws. The material is impervious to moisture, grease, and chemicals. PP is non-compostable and can be recycled, but not every recycling plant accepts the material.

Plastics number three and six are also BPA-free but are considered fewer safe plastics. Plastic three is Polyvinyl Chloride or PVC (Seaman, 2012). This material is flexible and relatively stable when hit by sunlight. The plastic has been called the "poison plastic" since it can leach several different toxins throughout its lifetime. PVC products like pipes and pipe fittings are typically repurposed instead of recycled. PVC is not recyclable or compostable. Plastic number six is Polystyrene (PS), and it is a cheap, lightweight, and easily formed plastic. Despite this, PS is not compostable or biodegradable Typically it is used to make one-use containers for food and drinks or as "packing peanuts." PS had been found to leach a carcinogen into food, especially when heated in a microwave. Consumer awareness has grown on this material based on the health hazards and harm to the environment, these products are no longer favored and are even banned in Costa Rica.

The final classification is plastics numbered seven. These products fall into the "others" category. Many of the plastics in this category are Polycarbonate and may contain BPA. Compostable plastics made from things like cornstarch also fall into this category; they do not contain BPA and are compostable (Seaman, 2012). This category may be confusing to consumers since a container numbered seven does not have a set recycling protocol and falls between two extremes, where the plastic could be dangerous for the consumer and the environment, or it could be composted and benefit the environment. The compostable plastics will be labeled number seven, but the abbreviation under the symbol will vary based on the polymer that the plastic is made from:

Figure 1: The circled section in the picture above shows very faintly the BPI label on a certified compostable product along with the composition and the BPA-Free number (PLA-7).

Compostable plastics are not recyclable. The diversity within category seven can make it difficult for a consumer to correctly manage the disposal of plastic products with this label.

2.4.3 BPI Certification Program

Gaining certification for compostable products is crucial to make sure items have been tested properly and meet international standards. Once an item has been certified, it can be identified as such by both the public and the private sector. The Biodegradable Products Institute, BPI, (2020) is the largest certifier of compostable products and packaging in North America.

Figure 2: Example of a BPI certified compostable logo for consumer products. Note the logo states "Industrial facilities… not suitable for backyard composting." Therefore, professional handling still required.

The BPI certification program ensures that BPI-labeled products and packaging have been tested and verified accordingly under the American Society for Testing and Material, ASTM, standards. For the item to be BPI-labeled, it needs to pass under ASTM D6400, which outlines the specifications for labeling of plastics that can be composted aerobically, and ASTM D6868, which outlines specifications to test for compostable plastic coatings. The certification marking offers an environment-friendly end-of-life opportunity for compostable items that would often end up in landfills. Furthermore, passing under these two standards validates that the item is safe to be composted and recycled back into the soil.

2.5 Strategies to Reduce to Plastic Pollution

To try and preserve the country's biodiversity, Costa Rica has begun implementing some potential solutions to the problem of plastic pollution. Some of the methods they have worked with have come in the form of a virtual currency, plastics that physically breakdown faster, and a

plastic-eating enzyme that allows for easier composting of plastics. Despite these efforts, there is still a disconnect between the public's desire to push for a better waste management system and the country's desire to educate the public on the various waste management methods. In this section we will discuss what Costa Rica has been doing to reduce plastic pollution.

2.5.1 Oxo-Plastics

One of the main ways to reduce plastic pollution is to manage the chemical composition of plastics. The reason plastic is considered a pollutant is due to the materials inability to be broken down into low molecular weight molecules that can be utilized by microorganism and broken down into CO2 and biomass (Abdelmoez et al., 2021). The research behind oxo-plastics may be a step toward the answer. Oxo-plastics are petroleum-based polymers that contain additives, typically metal salts containing transition metals like iron, nickel, and manganese. The addition of the metal will aid in the abiotic process that breaks down the plastic into small fragments. There is evidence that current research fails to support the notion that oxo-plastics break down into fragments that are small enough for microorganisms to break them down into water, carbon dioxide and biomass. Despite the current studies that show that a 15mm piece of prooxidant (oxo) LDPE biodegraded 91% into the soil versus the 43% for standard LDPE over two years, this additive may not be the complete answer to plastic pollution (Jakubowicz et al., 2011). The additives may speed up the process for the abiotic portion of biodegradation, but the biotic portion requires the fragments to be a particular size. The ability of the additive to break down the molecules into that size has not been consistently recorded. Other studies also support that the fragments from oxo-plastics are not of a small enough molecular weight to be used by microorganism (Musioł et al., 2017). If this is the case, the problem of microplastics could

continue to grow. The conditions required for oxo-plastics to break down are also important. The products become significantly less biodegradable in dark, acidic places. This makes landfills a very unfavorable environment, and oxo plastics that are thrown in a landfill may not biodegrade (Finzi-Quintao et al, 2016).

2.5.2 PETase

Modern research has allowed scientists to biologically engineer a plastic-eating enzyme that would aid in the biodegradation process. At its core, plastic degradability is not physically possible without a catalyst for its chemical breakdown process (Knott et al., 2020). Plastics never fully decompose, rather they break down into such small particles that they are no longer visible to the naked eye, but they are still there. These small particles, despite not being visible, hurt the soil around them because they don't allow for proper air and nutrient flow. PET, or polyethylene terephthalate, is a common plastic found in bottle containers and packaging. The team of Professor John McGeehan, University of Portsmouth, and senior research fellow, Gregg Beckham, re-engineered an enzyme called polyethylene terephthalate hydrolase, or PETase, which allows for faster breakdown and digestion of plastics (Guard, 2020).

In response to plastic pollution, microbes provide a helpful resource in producing synthetic polymers that can be broken down and used as energy sources down the line (Knott et al, 2020). PETase can act as an additive in PET plastics, therefore making them more commonly compostable. The reason behind this is because the enzyme speeds up the chemical breakdown process. Once a plastic is composted, it can take up to hundreds of years to decompose if not under the right conditions, but when this new microbial enzyme is added into the product's chemical composition, the microorganisms in the soil can now feed on this plastic because the

enzyme has broken down the product into its nutrient parts (Knott et al, 2020). Although this enzyme may not apply to all plastics produced, it does shine a light on what the future of enzymatic engineering may hold in the conversion to zero plastic waste.

2.5.3 Recycling Methods in Costa Rica

While people may think that the plastic they buy is going to be recycled, the reality is that most of it ends up in the ocean harming the environment. Even though Costa Rica is a rather small country, its contribution to worldwide pollution isn't trivial. In fact, one article said that Costa Rica produces 564 metric tons of plastic waste per day (Ocean Conservancy, 2018). Less than 2% of that (14 metric tons) is recycled; the rest goes to landfills, sewers, rivers, and seas. One of Costa Rica's biggest problems when it comes to plastic is that most plastics need special facilities to be properly recycled. The problem is Costa Rica does not have any of these facilities, so there is no domestic location for Costa Ricans to send or bring the plastics to be recycled. Shipping the plastics somewhere else to get disposed of would force the country to allocate funds to properly dispose of the plastic somewhere else, where there is no guarantee that the plastic is being handled properly.

2.5.4 Ecoins

To gain the public's interest, Costa Rica began incentivizing recycling with a virtual currency. In 2018, Costa Rica launched Ecolones, or Ecoins, as an initiative to promote at-home recycling amongst residents (Earth University, 2018). These Ecoins translate to a fiscal value directly correlated to the number of recyclables one has produced. An example of such can be seen here:

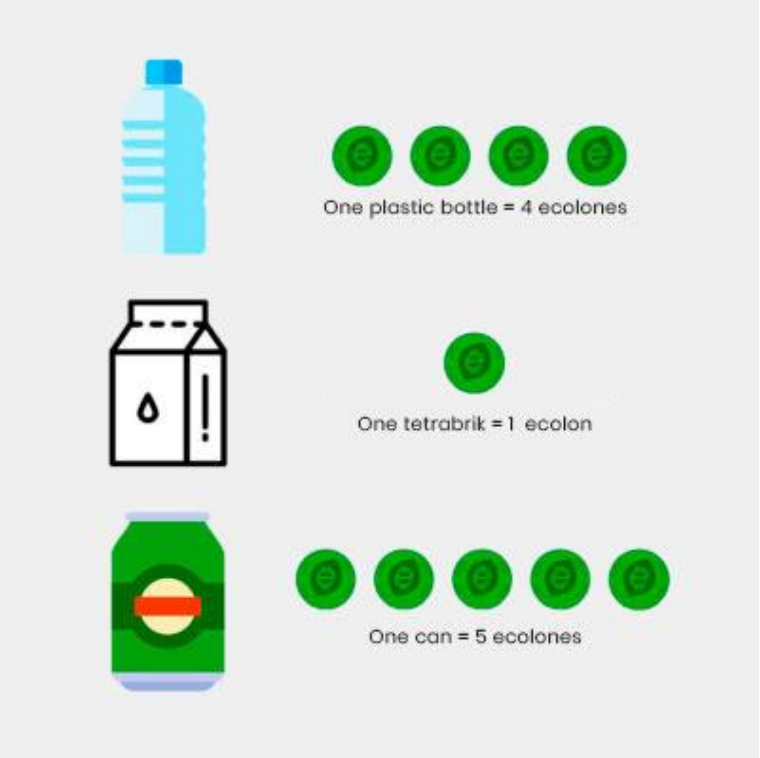


Figure 3: Depicting Common recyclables and their Ecoin value (Earth University, 2018).

The customer is required to clean out and separate all recyclable products from plastics, paper, glass, and aluminum. Once the recyclables are dropped off at one of the collection sites, the workers at the site evaluate the drop-off and provide the customer with a point value in Ecolones. But there wouldn't be much public interest if this virtual currency wasn't expandable. With that said, the Ecoins initiative in Costa Rica is partnered up with various commercial establishments who would accept the Ecolones as payment for products or merchandise. Businesses such as restaurants, supermarkets, and movie theaters even began providing discounts and coupons for customers who redeemed their Ecolones. A program like this provides incentives to recycle and keeps the public engaged in Costa Rica's eco-friendly identity.

2.5.5 Effects of Covid-19

In 2010, the Government of Costa Rica published its own Integrated Waste Management Law to try to promote a circular economy, which showed progress every year until the Covid-19 pandemic hit and companies began going out of business (Huisman et al, 2021). The municipalities are responsible for the collection, transportation, and treatment of solid waste, however only 87 of the 488 districts of Costa Rica have this municipal program (Huisman et al, 2021). This means that a lot of the smaller districts that don't have the funding for proper waste management systems have to find other methods of handling their waste without the help of municipalities. Examples of this may include burning garbage, which can release harmful greenhouse gases into the environment, or even just disposing of it into bodies of water where it will begin to accumulate and affect the water quality (Huisman et al, 2021). The challenge then becomes, how do we stop this problem from getting any worse? The public needs to be educated on proper waste management methods when such municipal programs are not offered. Due to the pandemic, many of these processing facilities are no longer working at full capacity because of low demand for materials such as cardboard, whereas for plastics there is not enough collected material to process (Huisman et al, 2021). If the public isn't receiving clear information on where and what items can be recycled rather than discarded with the rest of the garbage, then recycling and waste management systems are not going to be used to their full effects. For this reason, some organizations are beginning to campaign for proper waste management methods and are taking it into their own hands to educate the public.

2.6 MarViva Foundation

The MarViva foundation is an active non-profit and non-governmental organization founded by philanthropists in Central American countries such as Costa Rica, Panama, and Columbia, working to improve marine and environmental conservation efforts (EIA, 2020). MarViva has recognized the barriers that hinder the spread of knowledge between government and marine-user sectors at not only the local and regional levels, but at the global level as well. Through partnerships with various stakeholders, they promote responsible production and consumption of marine products, while at the same time pushing for the prevention of marine pollution via plastics.

2.6.1 The #ChaoPlasticoDesechable Campaign

In 2015, MarViva (2020) launched the #ChaoPlasticoDesechable campaign aiming to combat marine pollution through banning the usage of single-use plastics and advocating for improved waste management systems across the country. Translating to #GoodbyeDisposablePlastic, the campaign aims to provide more eco-friendly recycling techniques while also creating new public policies for consumers of the plastic industry to consider.

2.6.2 Knowledge Discrepancy

Costa Rica has become the largest plastic importer in Central America. Combined with a lack of proper disposal techniques or waste management facilities, much of the plastic waste ends up in oceans or landfills (MarViva, 2020). There are various new bioplastics available in Costa Rica claiming to be compostable and biodegradable; however, consumers are not aware

that most of these products require industrial composting facilities for complete processing to be achieved. Education on various plastic processing systems is vital to reducing the amount of plastic ending up in our oceans. Narrowing that knowledge gap can come in the form of various programs and initiatives that increase awareness of the ongoing problem. MarViva is doing just that.

To be effective, improving an environmental problem that is plaguing bodies of water all over Costa Rica requires the help of the greater community and not just individuals. A Costa Rican government press release revealed that to achieve a full ban on single-use plastic, the job cannot be done alone (EIA, 2020). Help needs to come from both the public and private sectors if an end goal of eliminating plastic waste in landfills and oceans is desired. Bodies such as the European Union (EU) and the United Nations Educational, Scientific, and Cultural Organization (UNESCO) have educational tools and resources readily available to the public, including the awareness of environmental issues (EIA, 2020). To be successful in tackling such a large issue like bioplastic pollution reduction, the fight starts with the governing bodies. Until the Costa Rican government begins to set aside more money and enforce stricter regulations, the public will continue to dump trash in the oceans and landfills, if there are no resources available to the public to help stop that. To close this knowledge gap, a variety of methods will be proposed in the next chapter. The strategies will be used to aid MarViva in their goal of educating and correcting the misconceptions that the public has on plastic use in Costa Rica.

3.0 Methodology

The goal of this project was to contribute to the development of a strategic plan through a public outreach campaign supported by the MarViva Foundation that would help educate the public sector to reduce plastic pollution across Costa Rica. To achieve the project goal, we identified the following set of five objectives:

1. Identify certifications on common plastics and their processing methods
2. Identify companies that are producing plastics that claim to be biodegradable or compostable and determine if the package labeling is supported by certifications
3. Determine the public sector's perceptions and understanding of plastics and proper methods of disposal in Costa Rica
4. Determine the knowledge, as well as misconceptions of plastics and biodegradability of commercial establishments partnered with MarViva
5. Develop a deliverable for MarViva to inform representatives of commercial establishments on biodegradability and plastic pollution

The following sections within this chapter outline and describe the means of achieving these objectives.

3.1 Identify Certifications on Common Plastics and their Processing Methods

One of the predominant goals was to align Costa Rica with similar certifications for plastic production and processing elsewhere. The more well-known certifications and standards include American Society for Testing and Materials, familiar in the United States of America,

International Organization for Standardization, known internationally, and European Norm which is followed in the European Union (ISO, 2021). Depending on the certifications being followed, plastic materials are required to meet specific standards before they can obtain a label (Van Der Werf, 2005). Extensive research was conducted through carefully viewing literature to list the differences between different processing methods and the certifications. The public could use the certification reference sheet to identify the proper disposal methods for plastics, as well as to determine which methods could be most beneficial in Costa Rica. From this information, a list could be produced for easy understanding of the way each plastic must be disposed of.

3.2 Performing Supermarket Visits to Identify Plastic Packaging and Labeling Certifications

A crucial method to help support consumer awareness was to analyze the products provided to the establishments where consumers shop. We visited approximately five supermarkets to find plastic products that claimed to be biodegradable, compostable, or oxo-degradable. The products were researched through the company websites to determine if the claims made on the products packaging had a certification to support it. If the products were not certified, then the consumers may have been purchasing products that they believed were biodegradable when they did not meet the certifications for being a biodegradable product. Consumer awareness may have been at a higher level than previously thought but misinformation on product labels leads to improper disposal.

3.3 Determine the Public Sector's Perceptions and Understanding of Plastics and Proper Methods of Disposal in Costa Rica

In order to conduct more research pertaining to the use of plastic products in Costa Rica, we gathered information on consumer awareness of plastics from the public community. However, to increase consumer awareness of plastics, we first determined how well the public understood plastics.

To do so, a short survey in Spanish with simple 'Yes' or 'No' or multiple-choice questions relating to plastics was put on social media with distribution help from MarViva's social media platforms. We were able to collect approximately a few hundred responses that could easily be compiled. The survey was created using Google Forms and a QR Code, not only to mitigate the spread of Covid-19 via surveying with pen and paper, but also allowed for the survey to be translated to English if needed. After viewing the answers to following survey questions, we were able to identify the common misconceptions that the Costa Rican public had on plastics and bioplastics.

We also acquired statistical data including how often the public uses plastics and how often they recycle the plastics that they bought. Therefore, this survey of the public sector furthered our research on finding solutions on how to reduce the use of plastic pollution, due to these perceptions that existed amongst the Costa Rican population.

3.4 Determine the Knowledge, as well as Misconceptions of Plastics and Biodegradability of Commercial Establishments Partnered with MarViva

Along with gathering information from the public sector through surveys, we conducted interviews with the representatives of four commercial establishments partnered with the

MarViva Foundation via Zoom: Celajes, Hotel Harmony, Hotel Olas Verdes, and Pueblo Dorado. The interviews were conducted using open-ended questions about plastics, including their environmentally friendly/sustainability practices, the amount and type of plastics these companies used, as well as their thoughts on the education and knowledge of plastic products. The purpose of these interviews was to get insight of whether big-named companies understood they types of plastics they use and the potential threat they pose on the current plastic pollution concern that is apparent in Costa Rica. Thus, the information obtained helped us understand what recommendations are needed to educate the commercial establishments about how to contribute to increasing consumer awareness on alternatives, bioplastics, and proper disposal methods.

3.5 Develop a Deliverable for MarViva to inform Representatives of Commercial Establishments on Biodegradability and Plastic Pollution

The gathered information, we developed a deliverable with infographics for MarViva to hand out to representatives of partnered commercial establishments, as well as to the general public. This deliverable would be used to educate Costa Rican population about the different types of plastics, recyclability versus biodegradability versus composability, and proper disposal techniques. With the lack of education and legislative backing, we hope that this deliverable contributes in widespread awareness and educating the newer and younger generations to hopefully reduce plastic pollution in Costa Rica.

3.6 Methods Summary

During our time in Costa Rica, these objectives and methods were subject to change. However, our goal for this project remained the same in helping the MarViva Foundation reduce plastic pollution across Costa Rica. While in Costa Rica, we used a bevy of methods to collect data that could be beneficial for MarViva. Information on certifications was still being researched through literature review. Using this information, we were able to visit supermarkets to observe the available plastic products for the certifications researched. Next, a consumer survey was used to collect information regarding the common misconceptions amongst the Costa Rican population. These survey responses were collected from both in-person, as well as through MarViva's social media platforms. Additionally, interviews via Zoom with the representatives of the four commercial establishments partnered with MarViva helped to reveal information on how businesses managed plastic and the misconceptions or issues with plastics that are commonly observed with their customers. Finally, a deliverable with infographics for MarViva was developed to correct the misconceptions that were prominent in the Costa Rican public sector.

4.0 Results and Analysis

The following chapter highlights the results we collected from executing our objectives as mentioned in the previous chapter. From the data and information we gathered, all was compiled and split up into different sections for ease of analysis. These sections correspond to the objectives listed in section 3.0 Methodology and present how we were able to complete each of our objectives and reach our goal of minimizing the knowledge gap in order to reduce the amount of plastic being disposed of improperly.

4.1 Product Certifications Analysis

Based on visits to supermarkets like Walmart, Auto Mercado and Fresh Market, we found that there was a large selection of plastic products that claimed to be compostable or biodegradable. We also noticed that larger supermarket chains had a larger selection and likely more access to these products. Some of the most prominent companies that claimed to have biodegradable products were, ‘Polipak’, ‘BioWare’, ‘Eco Sunrise’ and ‘Kanguro.’ After researching the products and speaking with Alberto Quesada, MarViva’s Policy Advocacy Advisor and Technical expert on ISWM public policy with an emphasis on single-use plastics and marine litter, that only two of these companies had official biodegradable certifications. Polipak, BioWare and Eco Sunrise all had at least one official certification under ISO, ASTM or BPI, supporting the biodegradability of the products. Kanguro products did not have official certifications but claimed to be biodegradable. This information should be noted, but it does not mean that the products should be dismissed as viable options for biodegradable products, since it is possible that the companies are in the process or have not attempted to receive a certification. Alberto also helped us gather information on the viability of particular products, specifically

biodegradable trash bags. The interesting thing about these is that they are only truly beneficial if they are filled with other compostable products that can be composted. Since the bags require specific conditions to completely biodegrade, they cannot be left in landfills. They would also have to be filled with organic or compostable waste so they can be processed by a composting facility. Assuming that research supports that oxo-biodegradable products can be composted, these products could also be included. OXO products can easily be determined through the label that is on them that will read ‘D2W’. We have included examples of the products manufactured by the companies mentioned and a spread sheet of their certifications:

Figure 4: The photo above captures straws produced by the company Eco Sunrise which claims to be biodegradable but only carries ISO certifications.

Figure 5: The product above is a collection of utensils (forks, spoons and knives) branded great value with a BPI certification.

Great value products are a brand that stems from Walmart and also has selections of biodegradable plates and bowls.

Figure 6: Termoencogibles trash bags are captured above. These products contain the D2W label on them indicating that they are oxo-biodegradable. The company offers different sizes and quantities of bags.

Figure 7: Above is a package of plates made by a Costa Rican company called Bioware. These products claim to be biodegradable but the information on their certifications could not be found and the website provided by the company seems to be incomplete.

Figure 8: Polipak Cups are captured above. Polipak products consist of utensils, cups, plates and bowls. These products are oxo-biodegradable and receive a D2W label to indicate composition of the plastic.

Table 1: Common brands found in Costa Rica along with the certifications the products carry.

Brand	Certifications & Disposal			
	BPI (Biodegradable)	ISO	D2W (Oxo-Biodegradable)	BPA-Free 1,2,4 and 5 (Recyclable)
BioWare	NO	Insufficent evidence	NO	NO
Polymer (Polipak)	NO	ISO9001 ISO14001	YES	NO
Great Value (Cups)	NO	ISO9001	NO	YES
Great Value (Utensils)	YES	ISO9001	NO	NO
Link	NO	Insufficent evidence	NO	NO
Eco Sunrize	NO	ISO9001 ISO14855	NO	NO
Super Max	NO	Insufficent evidence	NO	NO
Term Encogibles (Trash Bags)	NO	ISO9001 ISO14001	YES	NO
Kanguro	NO	NO	YES (some)	NO
Zesta	NO	ISO9001 ISO14001	YES (some)	NO

The table above is an organization of brands in Costa Rica that claim to be biodegradable or recyclable along with the certifications they do or do not carry. The certifications and labeling standards are listed on top and state whether the products are certified. The table also contains ISO certification to indicate if the companies are working toward sustainable products and practices.

4.2 Plastic Products versus Other Alternatives

Through observation at local supermarkets and grocery stores we recognized that the price difference between convention plastic products and other alternatives is small, at least when not purchasing in bulk. In the case of Oxo- biodegradable products, for packs of eight to twenty-four cups, utensils or plates fell within the range of 300 to 700 colones which was slightly less than the price range for conventional plastic products containing the same quantity. One other observation was that there were few options to purchase large amounts of Oxo-biodegradable or biodegradable products in the supermarkets, making these products less likely to be purchased by consumers looking for a large quantity of products. Similar trends were seen in other products like garbage bags. Having found that there are no insignificant differences between the prices for the sustainable products and conventional products, we tried to discover why consumers continued to purchase conventional products.

4.3 Consumer's knowledge about plastics

A brief survey was sent out to both the consumer and producer sectors to highlight the understanding and misconceptions locals have about plastic disposal in their country. The initial goal was to send out the survey via the MarViva social media page and obtain about 100

responses from various individuals across Costa Rica who use plastics daily. The release of the survey on MarViva media was delayed significantly and originally only 30 in-person responses were collected. After being posted for about three days, 121 additional responses were collected providing a large enough sample size. The first few questions included in the survey were added to aid MarViva in understanding the gender, age and location of the citizens that completed the survey. The rest of the questions can be divided for analysis by consumption, awareness, and disposal.

4.3.1 Consumption

The consumption aspect of these questions included information on what plastics are typically purchased, why they are purchased and how often they are purchased. The first question relating to this asked about the frequency of which plastics are purchased. The responses for this question came back as expected and about 75% of the responses indicated that plastic is always or almost always part of merchandise that is purchased when shopping.

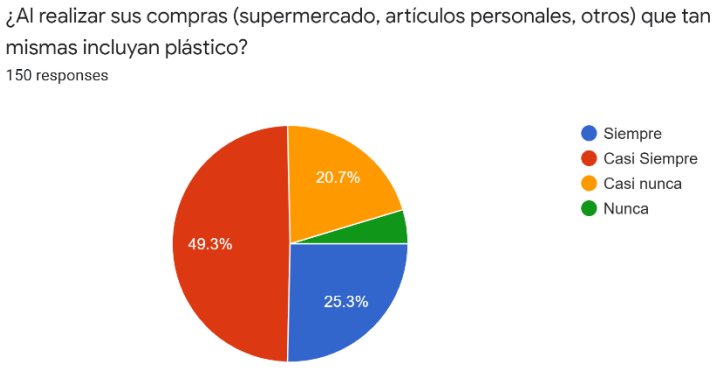


Figure 9: The pie chart above contains the results from the following question. In English the question reads, "When making your purchases (supermarket, personal items, others) how often do they include plastic?" The answers in English are Always, Almost Always, Almost Never and Never respectively.

The next question that falls under the consumption category asked on what base the individuals select the plastic that they purchase. According to the responses about 25% of the respondents claim to select the plastic based on the certifications that the plastic carries while 47% select the plastic based on some type of visual aspect whether it be the brand (light blue), Package design (red), advertising (purple) or the label (orange). Including all the other responses, this indicates that more than half of the respondents are either not aware of or do not care about the certifications given to plastic items.

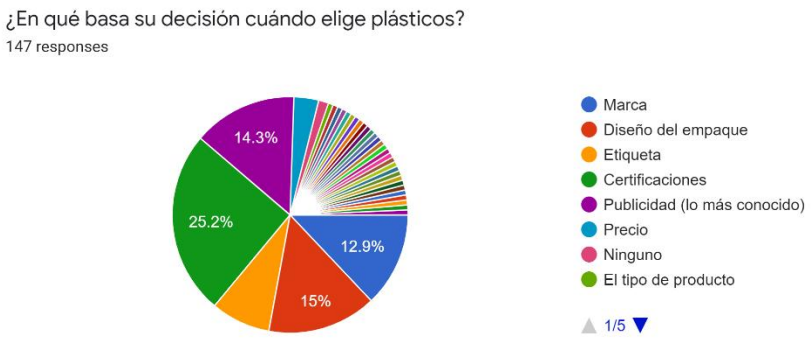


Figure 10: The pie chart above contains the results from the following question. In English the question reads, “On what do you base your decision when choosing plastics?” The answers in English are Brand, Packaging design, Label, Certifications, Advertising, Price, None, Type of product in that order.

4.3.2 Product Awareness

Understanding which plastic products that Costa Rican citizens know of and have access too is important to determine which options are most suitable for elevating awareness. The first question was used to determine the selection of products that customers noticed were available ranging from conventional plastics to OXO-biodegradable plastics.

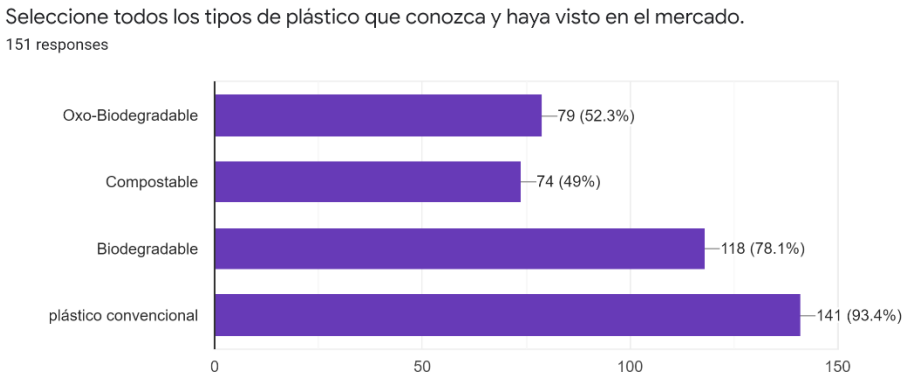


Figure 11: The horizontal bar graph above contains the results from the following question. In English the statement reads, "Select all types of plastic that you know and have seen on the market."

The data collected from this question showed that almost all respondents were familiar and recognized conventional plastics in supermarkets along with 75 percent of them recognizing biodegradable options. Even with the large market of Oxo-biodegradable options only about 50% of the respondents were familiar with the option. Along with this only 50% of the respondents recognized compostable plastics in the stores. The question related to which plastic had the worst effect on the environment yielded unexpected results but also supported the idea that there are misconceptions are a part of the issue when it comes to plastic awareness in Costa Rica. As of right now the plastics that cause the least environmental damage would be compostable plastics but only when disposed of properly do the survey results show that Costa Ricans are aware of this. Just under 40% of the respondents selected compostable products to be the least harmful to the environment. The next 50% of respondents selected biodegradable or oxo-biodegradable as the products as the least harmful. While 6% still think that conventional plastics are the least harmful. The split between those who selected compostable and biodegradable products could be due to a lack of education and it is something that differentiated. This notion that biodegradable products are the least harmful is a misconception

that is only present due to the difference in time and conditions required to make a biodegradable product into a compostable product.

Figure 12: The pie chart above contains the results from the following question. In English the question reads, "Which of the following plastics do you consider to be the least harmful to the environment?"

The most concerning question was about the viability and safety of bioplastics. The survey asked if the respondents believed that bioplastics were a safe alternative to conventional plastics. Only 13.3% responded no, indicating that they are not a safe alternative. 34.7% did not know and the last 52% believed that bioplastics are a safe alternative which is not true. This is knowledge that must be corrected to increase awareness. Bioplastics are made from more sustainable practices but they are still just as harmful as conventional plastics when the same disposal practices are used.

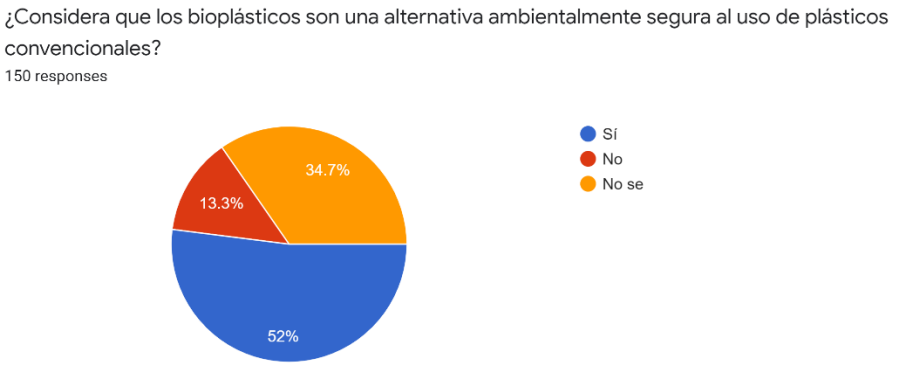


Figure 13: The pie chart above contains the results from the following question. In English the question reads, "Do you consider that bioplastics are an environmentally safe alternative to the use of conventional plastics?"

The last question based on awareness asked if plastics could be harmful to humans. The response to this question showed that the respondents had an exceptionally good understanding that plastics are not exactly as safe as they seem. About 87 percent of the responses understood that plastics could be harmful to humans one way or another. 10.6 percent stated that they did not know and the final 2.6 percent did not think that plastic could be harmful.

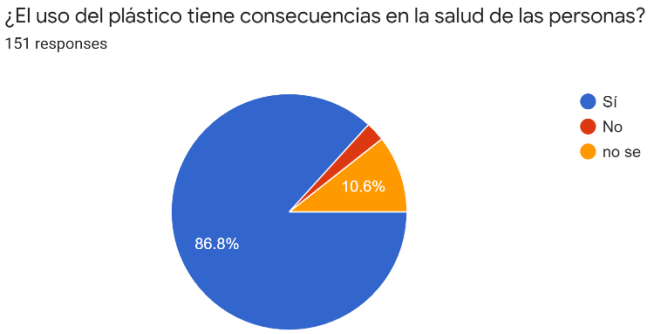


Figure 14: The pie chart above contains the results from the following question. In English the question reads, "Does the use of plastic have consequences on people's health?"

4.3.3 Disposal

Disposal of plastic items was the final category that data was collected in. The misconceptions behind compostable plastics were tested and the first question relating to disposal asked how often compostable plastics could be composted at home. Home compost containers rarely meet the correct conditions for plastics to be composted yet, almost 15 percent of the respondents believe that these plastics are always compostable at home, and another 28 percent believe that compostable plastics can be composted at home most of the time.

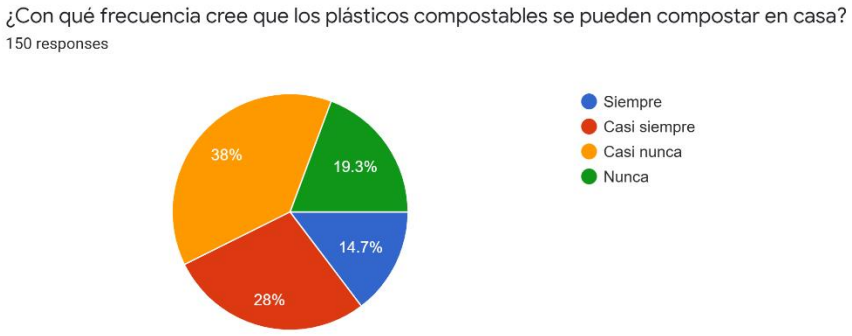


Figure 15: The pie chart above contains the results from the following question. In English the question reads, “How often do you think compostable plastics can be composted at home?” The answers in English are always, almost always, almost never and never in that order.

The other question based on disposal that yielded interesting results had to do with the methods that the individuals used to dispose of plastics. The results of this question suggested that disposal of plastic materials in Costa Rica is well understood. About 83 percent of the respondents suggested that they recycled the plastic that they use, while another 65.6 percent claim that they recycled the plastic they use. Under 50% of respondents selected that they discarded the plastic into the trash and only 6 percent indicated that they composted plastics. There was one “other’ answer that came up a few times. This disposal method is known as Ecoblocks, which is simply

the collection of non-recyclable plastic in a 1.5L to 2.5L plastic bottle that can be turned in for rewards.

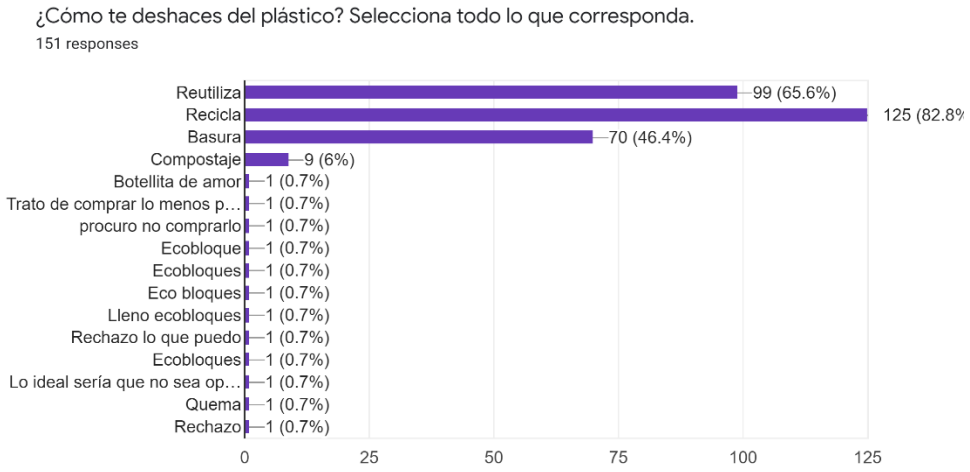


Figure 16: The horizontal bar graph above contains the results from the following question. In English the question reads, “When making your purchases (supermarket, personal items, others) how often do they include plastic?” The answers in English are reuse, recycle, trash, and compost. The only other answer that received more than one selection was Ecobloque which translates to Ecoblock.

4.4 Commercial Establishment Interviews

From the interviews conducted, the answers from each interviewee were compiled and condensed for ease of analysis. From these interviews we were able to gain insight into educational methods, internal changes, product inventory, and usage and disposal methods of commercial establishments partnered with the MarViva Foundation. Through these interviews we were able to gain the necessary information backup our initial research. The following sections will highlight the topics covered and the key takeaways that we got from these interviews.

4.4.1 Education Methods

Due to misconceptions that several Costa Ricans face when handling and disposing of plastics, we asked four commercial establishments their opinions on whether education on proper disposal methods and plastic education should be more widespread.. Maria Aguilar, from the Pablo Dorado Surf Hotel informed us that plastic education, specifically proper disposal methods, are not commonly taught in school. This poses a problem for the coming generations if the sole source of education on proper disposal methods for plastics comes from parents. Although this may not be a problem in all cases, often parents will not have the same level of knowledge on proper disposal methods as a plastic manufacturing and processing company. Representatives from both Hotel Olas Verdes and Hotel Harmony, mentioned that many school systems lack the policies to require education about plastics in their curriculum. The result is that an exorbitant number of plastics end up in the rivers and waterways where they do not belong. Daniel Rojas from The Harmony Hotel suggested that education should be conducted by young experts and environmental activists because with their passion and experience there is an opportunity to convince others to push for a change and help protect the environment as well. Maritza Sanchez, from the Celajes Bar and Restaurant in Nosara, stated that only recently has education about plastics in schools begun. Maritza mentioned that the town organizes clean-ups of beaches and rivers approximately 5 times a month. On top of this, the school system in Nosara has begun bringing in parents to educate them and their children on various topics, one of them being proper waste disposal and sustainable practices. Efforts like these will reinforce the importance of keeping the environment a clean and safe place for all types of life, not just humans and animals, but plant life as well.

4.4.2 Changes to Traditional Practices

Four of the establishments we interviewed are partnered with MarViva and have made efforts to change their practices and training emphasis with their employees. All the establishments stated that training is given to the employees who will be handling plastics on proper separation and disposal. Since they have been affiliated with MarViva, some even had this implemented prior to joining the #ChaoPlasticoDesechable campaign. A substantial effort for separation of metals, plastics and organics has become a normal practice in these establishments and at many others around Costa Rica. Many locations now have color coded receptacles to indicate what is to be put in it to minimize the amount of manual separation after disposal. Through our interviews we also confirmed that all the establishments have tried to minimize the purchase and usage of plastics. Restaurants use wood or ceramic plates, metal straws, glass cups and have even made efforts to offer regular customers reusable glass containers to bring home and return on their next visit. Many of the hotels have tried to manage plastic waste by providing drinks in glass cups instead of giving the customers plastic bottles. Any large drink containers are handled by the establishment and will be disposed of properly without relying on the customers. Some locations have even tried to decrease the distribution of snacks that are packaged in plastic. These sustainable practices have contributed to an increase in business at some establishments since they now attract the regular as well as the nature loving clientele.

4.4.3 Typical Product Types Available

Based on our interviews with the four commercial establishments partnered with MarViva, one of the many similarities that surfaced is the minimal use of plastic products; they

provide their guests with a bevy of alternatives instead. Some of these alternatives that most of these establishments provide include non-plastic tableware and utensils, such as ceramics, metal, wood, glass, etc. For example, Celajes, a restaurant located in the Nosara region, uses metal straws and wooden tableware when foods and drinks are served to their customers. Similarly, Hotel Harmony offers bamboo straws and a glass for drinks that are provided to their guests. According to Daniel Rojas, the Sustainability Coordinator of Hotel Harmony, they were the first hotel in Costa Rica that developed the idea of using bamboo straws, which other establishments started to take after. Meanwhile, Pueblo Dorado Surf uses recyclable cups instead because drinks served in glasses that were consumed by the pool, this became dangerous as guests would leave them out and they would break in the pool area where people would be walking around without footwear. Even with some alternatives to replace the use of some plastic products, not all plastic products have been completely phased out, such as containers and packaging, garbage bags, and cleaning and disinfection products. However, these plastic products are recycled correctly by the commercial establishments. As an example, the products used by the Olas Verdes Hotel are an indication of how much plastic is being used by the establishment. The tables below provide the list of plastic products used by two hotels:

Table 2: List of plastic products with respective plastic numbers from Hotel Olas Verdes.

Números de plástico		
ITEM	UNIDAD DE MEDIDA	# de plástico
Alcohol Liquido	GALON	4
Alcohol en Gel	GALON	4
Atomizadores - botellas plasticas	BOTELLA	2 HDPE
Atomizadores - cabezas	UNIDAD	No tiene numero
Bolsa blanca grande Ecomax	PAQUETE	No tiene numero
Bolsa blanca mediana Ecomax	PAQUETE	No tiene numero
Bolsa jardín Negra	PAQUETE	No tiene numero
Bolsa Jardin Transparente	PAQUETE	No tiene numero
Bolsa transparente mediana	PAQUETE	No tiene numero
Bolsa roja residuos biologicos	PAQUETE	No tiene numero
Desodorante Nature Fresh	GALON	2 HDPE
Limpiador - Desengrasante	GALON	2 HDPE
Limpiador de vidrios	GALON	2 HDPE
Limpiador - Pulidor Biobrass	LITRO	1
Jabon Liquido para manos (rojo)	PICHINGA	02 PE-AD
Lavaplatos (para rellenar botellas)	PICHINGA	02 PE-AD
Limpiador - Desinfectante Florex	PICHINGA	02 PE-AD
Limpiador - Silicon abrillantador	PICHINGA	02 PE-AD
Limpiador de Ceramica	PICHINGA	02 PE-AD
Limpiador Multiusos Florex	PICHINGA	02 PE-AD
Ropa - Blanqueador	PICHINGA	02 PE-AD
Ropa - Detergente para Lavar	PICHINGA	02 PE-AD
Ropa - Suavizante	PICHINGA	02 PE-AD
Stain killer	BOTELLA	3 HDPE
Ropa - Desengrasante Bluetech	GALON	4
Ropa - Desmanchador SK-02	120 ML	2 HDPE
Ropa - Desmanchador SK-03	950 ML	3 HDPE
Sabila - Acondicionar	GALON	2 HDPE
Sabila - Gel de bano (ducha)	GALON	2 HDPE
Sabila - Jabon Liquido Bano	GALON	2 HDPE
Sabila - Shampoo	GALON	2 HDPE

Table 3: List of plastic products with the amount used from Hotel Olas Verdes.

INVENTARIO FISICO MENSUAL DE AMA DE LLAVES Dec-21					
ITEM	UNIDAD DE MEDIDA	QTY INICIAL	QTY COMPRAS	QTY FINAL	TOTAL USADO
Alcohol Liquido	GALON	2.0	2	1.2	2.8
Alcohol en Gel	GALON	5.5		3.8	1.7
Atomizadores - botellas plasticas	BOTELLA	6.0	6	12.0	0.0
Atomizadores - cabezas	UNIDAD	6.0	6	5.0	7.0
Bolsa blanca grande Ecomax	PAQUETE	16.0		6.0	10.0
Bolsa blanca mediana Ecomax	PAQUETE	53.0		0.0	53.0
Bolsa jardín Negra	PAQUETE	0.0	36	29.0	7.0
Bolsa Jardin Transparente	PAQUETE	17.5	12	7.0	22.5
Bolsa transparente mediana	PAQUETE	87.0		30.0	57.0
Bolsa roja residuos biologicos	PAQUETE	40.0	6	46.0	0.0
Desodorante Nature Fresh	GALON	2.0	8	0.5	9.5
Limpiador - Desengrasante	GALON	4.0		3.0	1.0
Limpiador de vidrios	GALON	3.0	2	3.8	1.2
Limpiador - Pulidor Biobrass	LITRO	3.0		3.0	0.0
Jabon Liquido para manos (rojo)	PICHINGA	1.0		0.9	0.1
Lavaplatos	PICHINGA	2.4	0.6	3.0	0.0
Limpiador - Desinfectante Florex	PICHINGA	2.4	1	1.9	1.5
Limpiador - Silicon abrillantador	PICHINGA	1.9		0.5	1.4
Limpiador de Ceramica	PICHINGA	1.5	2	1.3	2.2
Limpiador Multiusos Florex	PICHINGA	2.0		1.5	0.5
Ropa - Blanqueador	PICHINGA	1.0	1	1.2	0.8
Ropa - Detergente para Lavar	PICHINGA	0.5	3	1.2	2.3
Ropa - Suavizante	PICHINGA	1.8		1.2	0.6
Stain killer	BOTELLA	2.0		2.0	0.0
Ropa - Desengrasante Bluetech	GALON	0.0	3	1.0	2.0
Ropa - Desmanchador SK-02	120 ML	3.0		3.0	0.0
Ropa - Desmanchador SK-03	950 ML	0.0		0.0	0.0
Sabila - Acondicionar	GALON	3.5	1	1.0	3.5
Sabila - Gel de bano (ducha)	GALON	0.6	4	2.0	2.6
Sabila - Jabon Liquido Bano	GALON	5.0		4.0	1.0
Sabila - Shampoo	GALON	4.4		1.1	3.3

With the information provided by the Olas Verdes we learned that although they follow sustainable practices, they do not use environmentally compostable plastics that are categorized as number 7. Although they may not be using compostable products, they dispose of their plastics properly, and recycle and reuse them whenever possible.

4.4.4 Usage and Disposal of Plastics

Each establishment we reflected on the usage and disposal of plastics they see on a daily basis. Pueblo Dorado Surf Hotel has a designated person in charge of gathering the garbage in mornings and afternoons and separating the recyclables, organic waste, compostable items, etc. This waste is then then picked up once a week by the designated waste management company. Olas Verdes, Harmony, and Celajes all follow the same procedures with the waste that is produced at their establishments. All of them provide information to the guests/customers who arrive at their establishments that they are an eco-friendly business and that they follow sustainable practices. This is essential because it lets the people coming in know right away how business is handled. Staff at all establishments are fully trained on the separation of product waste. Since these establishments are located in or around nature reserves/ protected areas, the clientele is typically customers who know and want to follow sustainable practices as well. We asked all four businesses whether they thought there is still a large number of people who come in and do not follow the sustainable procedures mentioned to them upon arrival. All four interviewees immediately stated that this was not the case. Both Carol Garcia from Olas Verdes and Maritza Sanchez of Celajes mentioned that they don't receive much business from people who do not follow sustainable practices. These establishments attract customers who care about

the environment, so they can incentivize customers to follow their guidelines. Examples of this are seen at Celajes where recurring customers are given reusable containers, and in Olas Verdes where they provide customers with glass and ceramic utensils they can use and reuse for the length of their stay. Disposal and usage of plastics is all dependent on the people who come in, and since these establishments rely on their sustainable practices, they serve as excellent examples of eco-friendly business – consumer relationships.

5.0 Conclusion & Recommendations

In this chapter we will highlight the key takeaways upon completing our objectives with MarViva and the public sector in San Jose, Costa Rica. To remain resilient, and push for more sustainable efforts in the country we also came up with a few recommendations that MarViva can look into and advocate for. These key takeaways and recommendations will be covered in the following two sections.

5.1 Conclusions

Through surveys, interviews, and product analysis a large amount of information was gathered relating to the misconceptions of conventional plastics and bioplastics. Although biodegradable and compostable plastics are not the perfect solution to the pollution issue, they are a better alternative to conventional plastics. One misconception had to do with the price difference between conventional plastics and more environmentally friendly options. The product analysis supported that the price is about the same and should not be a problem when deciding between conventional plastics and biodegradable or compostable plastic. The surveys allowed us to directly identify specific misconceptions that the public had about plastics and bioplastics. The misconceptions particularly related to awareness and disposal of bioplastics. The survey brought to light the lack of knowledge within the population when dealing with disposal of compostable plastics and when recognizing the similarities between conventional plastics and bioplastics. From the commercial establishment interviews, it was revealed that all four locations in Nosara, Costa Rica were environmentally conscious. These four commercial establishments partnered with MarViva adopted environmentally friendly/sustainability practices to reduce plastic pollution. For example, providing customers and guests with alternatives to plastic products, such as bamboo or metal straws instead of plastic or paper straws, glass or wooden

cups instead of plastic or Styrofoam cups, wooden tableware utensils instead of plastic tableware and utensils, etc. Through conducting these interviews with the representatives over Zoom, they also believed the reason Costa Rica lacks the knowledge pertaining to plastics is because there is a lack of education for the newer generations. Therefore, education and legislative support are necessary to limit those common misconceptions to reduce plastic pollution.

5.2 Recommendations

Based on the conclusions we came to in the prior section, were able to produce a few recommendations that MarViva and the Costa Rican community to consider. We believe these recommendations will push forward a new generation of environmentally safe practices in the plastics industry and help preserve beautiful wildlife and nature in Costa Rica. These recommendations are covered in the following sections.

5.2.1 BPA-free Labeling Update

We believe one of the most effective methods for identifying if a plastic is recyclable is the BPA-Free labeling system. The system was popularized in 2009 but it fails to account for the development of new plastic products. Plastics labeled one through six will likely be around for a long time and the composition can be easily identified as each number only applies to one plastic. The seventh category must be broken down into components or more numbers must be added to continue to get the most out of this system. Since the seventh category is a catch all for any BPA-free plastic that does not have the same composition as one of the first six, it makes determining the composition of the plastics in that category very difficult when consumers are holding the product in their hand. The recommendation would be to add a few more categories,

one that will indicate that the plastic is biodegradable, one that indicates the plastic is compostable and possibly one that indicates a plastic is a bioplastic. The compostable category could even be broken down further to account for different certifications that would indicate if the product could be composted at home or if it requires an industrial composting facility to be correctly processed.

5.2.2 Education and Widespread Awareness

Education about the damage that plastics cause to the environment is something that is essential to the success of any outreach program. As more individuals become educated on the topic of plastics, the misconceptions will start to disappear, and the number of proper disposal methods will increase. Those who can be educated in these topics are not obligated to relay the information they learned to others, but when the opportunity presents itself the individuals with knowledge should share what they know for the purpose of protecting the planet.

Another recommendation would be to begin a push to implement more environmental education on plastics and proper disposal in schools. This is not something that was taught to previous generations and the information that was never taught could not be passed down. The introduction of this type of education would increase awareness starting with the youth in schools who could carry the information and pass it on to future generations. More efforts must be made for citizens to understand the labeling on plastic materials. The identification of plastic products can easily be used to sort recyclable and non-recyclable products. If the BPA-free labeling is expanded, the information provided by the new numbers could also be taught and people would also be able to distinguish compostable and biodegradable products.

5.2.3 Greater Emphasis on R&D and Manufacturing in the Plastics Industry

Research and Development may be slightly out of reach for MarViva based on funding, but it is still something the organization could advocate for. Through research and development companies can discover and begin to manufacture materials with similar properties to plastics that are safer for the environment. After these materials are discovered, ways to extract or synthesis them can be worked on to reduce the cost to manufacture and sell the products. This way establishments and consumers would have a cheap and environmentally friendly option with similar qualities to current materials. Other options for research could be discovering additives like PETase or metals (OXO) that will increase the biodegradability of the plastic products that are currently used. As more products are developed, the current harmful products can be phased out, and disposal of the products will become less important. The research and development departments within the plastics industry are vital in keeping the production of one of the highest demanded products while protecting the planet.

5.2.4 Incentivize Specific Product Purchases

In attempt to get people to follow sustainable waste disposal methods, there should be an incentive to do such a thing. In 1953, the state of Vermont passed a bill that would place a deposit fee for glass bottles bought from the store. If the customer were to return their empty bottles afterwards to the store, then they would get their deposit back (Creem, 2021). This bill was expanded upon in the state of Massachusetts when it saw a 138% increase in curbside recycling costs over the past few years. With costs of recycling being high, most recyclables end up in the trash and later in landfills or incinerators, which are not safe for the environment. The bottle bill was later reformed to also place deposit fees on plastic bottles and aluminum cans as

well. With Costa Rica facing similar issues, if supermarkets were to raise the deposit fee on bottles, customers would be more willing to bring their bottles back and get their deposit money in return. This would not only benefit the customer, because they would not have to worry about the disposal of the bottle, it would benefit the environment as well, because the establishment would have the connections and the means to dispose of the product properly rather than just throw it in the trash. This is a winning situation on both sides because the establishments would have the opportunity to bring in more customers when they offer a service like this to their customers. Especially in a nature conscious country like Costa Rica, where protecting the environment around you is so important, a system like this could be a big breakthrough in the country's effort to educate the public on end-of-use product protocols.

References

Abbing, M. R. (2019). *Plastic soup : An atlas of ocean pollution*. Island Press. *https://ebookcentral.proquest.com/lib/wpi/reader.action?docID=6154228*

Abdelmoez, W., Dahab, I., Ragab, E. M., Abdelsalam, O. A., & Mustafa, A. (2021). Bio- and oxo-degradable plastics: Insights on facts and challenges. *Polymers for Advanced Technologies, 32*(5), 1981–1996. https://doi.org/10.1002/pat.5253

Anaheim Regional Medical Center (AHMC). (2016, November 30). What is BPA-free plastic? https://www.anaheimregionalmc.com/Blog/2016/November/What-Is-BPA-Free-Plastic-.aspx.

As You Sow. (2022). *Ocean Plastics*. https://www.asyousow.org/our-work/waste/ocean-plastics#:~:text=The%20ocean%20contains%20an%20estimated,flow%20of%20plastics%20into%20waterways.

BPI. (2020). *What is a certified compostable product?* Biodegradable Products Institute . https://bpiworld.org/products.html.

Center for Food Safety and Applied Nutrition. (2014). *Bisphenol A (BPA): Use in food contact application*. U.S. Food and Drug Administration. https://www.fda.gov/food/food-additives-petitions/bisphenol-bpa-use-food-contact-application.

Creem, C.S., Decker, M. (2021). *H.3289/ S.2149 Bottle Bill.* Conservation Law Foundation

EARTH University Foundation. (2018, May 2). *Costa Rica rewards recycling with "Ecolones"*. EARTH University. https://www.earth.ac.cr/en/2018/05/02/rewards-recycling-ecolones/.

Environmental Investigation Agency (EIA). (2020). *Convention on plastic pollution - Toward a new global agreement to address plastic pollution.* https://www.ciel.org/wp-content/uploads/2020/06/Convention-on-Plastic-Pollution-June-2020-Single-Pages.pdf

Finzi-Quintão, C. M., Novack, K. M., & Bernardes-Silva, A. C. (2016). Identification of biodegradable and oxo-biodegradable plastic bags samples composition. *Macromolecular Symposia*, *367*(1), 9–17. https://doi.org/10.1002/masy.201500156

Goel, V., Luthra, P., Kapur, G. S., & Ramakumar, S. S. (2021). Biodegradable/bio-plastics: Myths and realities. *Journal of Polymers and the Environment*, *29*(10), 3079–3104. https://doi.org/10.1007/s10924-021-02099-1

Guard, L. (2020). *PETase - Molecule of the Month December 2020 [Archived version]* (Version 1). Figshare.https://doi.org/10.6084/m9.figshare.12887087.v1

Huisman, H., Keesman, B., & Breukers, L. (2021). *Waste management in the latam region* . Holland Circular Hotspot. https://hollandcircularhotspot.nl/wp-content/uploads/2021/04/Report_Waste_Management_Costa_Rica_20210329.pdf

Information about sea turtles: Threats from Marine Debris. (n.d.). Sea Turtle Conservancy. https://conserveturtles.org/information-sea-turtles-threats-marine-debris/

ISO. (2021, January 22). *Members*. ISO. https://www.iso.org/members.html

IUCN. (2021, November 17). *Marine plastic pollution*. https://www.iucn.org/resources/issues-briefs/marine-plastics

Jakubowicz, I., Yarahmadi, N., & Arthurson, V. (2011). Kinetics of abiotic and biotic degradability of low-density polyethylene containing PRODEGRADANT additives and its effect on the growth of Microbial Communities. *Polymer Degradation and Stability*, *96*(5), 919–928. https://doi.org/10.1016/j.polymdegradstab.2011.01.031

Knott, B. C., Erickson, E., Allen, M. D., Gado, J. E., Graham, R., Kearns, F. L., Pardo, I., Topuzlu, E., Anderson, J. J., Austin, H. P., Dominick, G., Johnson, C. W., Rorrer, N. A., Szostkiewicz, C. J., Copié, V., Payne, C. M., Woodcock, H. L., Donohoe, B. S., Beckham, G. T., & McGeehan, J. E. (2020). Characterization and engineering of a two-enzyme system for plastics depolymerization. *Proceedings of the National Academy of Sciences*, *117*(41), 25476–25485. https://doi.org/10.1073/pnas.2006753117

Künkel, A., Becker, J., Börger, L., Hamprecht, J., Koltzenburg, S., Loos, R., Schick, M. B., Schlegel, K., Sinkel, C., Skupin, G., & Yamamoto, M. (2016). Polymers, biodegradable. *Ullmann's Encyclopedia of Industrial Chemistry*. https://doi.org/10.1002/14356007.n21_n01.pub2

Lallement, A., Vasmara, C., Marchetti, R., Monlau, F., Mbachu, O., & Kaparaju, P. (2021). Anaerobic digestion of bioplastics. *Clean Energy and Resources Recovery*, 253–270. https://doi.org/10.1016/b978-0-323-85223-4.00023-3

Lehigh University. (n.d.). *Fossil fuels*. ELI: Energy: Support Materials: Fossil Fuels. https://ei.lehigh.edu/learners/energy/fossilfuels/fossilfuels4.html.

Lindwall, C. (2021, April 20). *Single-use plastics 101*. NRDC. https://www.nrdc.org/stories/single-use-plastics-101#what

Posen, I. D., Jaramillo, P., Landis, A. E., & Griffin, W. M. (2017). Greenhouse gas mitigation for U.S. plastics production: Energy first, feedstocks later. *Environmental Research Letters*, *12*(3), 034024. https://doi.org/10.1088/1748-9326/aa60a7

The Center for Biological Diversity. (n.d.). *Ocean plastics pollution*. https://www.biologicaldiversity.org/campaigns/ocean_plastics/

Van Der Werf, P. (2005). Decomposition of Pandora's bag - Part 2. *Solid Waste & Recycling*, *10*(4), 30-33.

Appendix A: Plastic Consumer Survey Questions and Answers

Appendix A contains all the current survey questions that were used to survey the local customers as they exited supermarkets in San Jose, Costa Rica as well as the survey participants that responded through MarViva's social media post. At the convenience of the customer, the survey questions were provided in both English and Spanish, with a choice to complete the survey in either language. For the small portion of surveys done in person we waited outside of the exit of the supermarkets and as people exited if their hands were not full, we would introduce ourselves as university students that were working on a project with the MarViva foundation and asked if they would like to participate in an anonymous survey to aid us in our study. If they accepted, we would present them with the QR code that was created and thank them for their time as well as completing the survey. For those thtat declined we would thank them for their time and wish them a good day.

(Español)

1) Sexo
    a) Masculino
    b) Femenino
2) Edad
    a) 18-25
    b) 26-35
    c) 36-45
    d) 46-55
    e) 56-65
    f) Más de 65
3) Provencia
    a) Alajuela
    b) Cartago
    c) Guanacaste
    d) Heredia

e) Limón
f) Puntarenas
g) San José
h) Colombia

4) ¿Al realizar sus compras (supermercado, artículos personales, otros) que tan frecuente es que las mismas incluyan plástico?
   a) Siempre
   b) Casi Siempre
   c) Casi nunca
   d) Nunca
5) Seleccione todos los tipos de plástico que conozca y haya visto en el mercado.
   a) Oxo-Biodegradable
   b) Compostable
   c) Biodegradable
   d) Plástico convencional
6) ¿De los siguientes plásticos cuál considera es el menos perjudicial para el medio ambiente?
   a) OXO-Biodegradable
   b) Compostable
   c) Biodegradable
   d) Plástico convencional
   e) Todos impactan igual el medioambiente
7) ¿Cómo te deshaces del plástico? Selecciona todo lo que corresponda.
   a) Reutiliza
   b) Recicla
   c) Basura
   d) Compastaje
   e) Botellita de amor
8) ¿Con qué frecuencia cree que los plásticos compostables se pueden compostar en casa?
   a) Siempre
   b) Casi siempre
   c) Casi nunca
   d) Nunca
9) ¿Considera que los bioplásticos son una alternativa ambientalmente segura al uso de plásticos convencionales?
   a) Sí
   b) No
   c) No se
10) ¿Cuáles opciones le parecen mejor para disminuir el uso de plástico?
   a) Bio-Plásticos
   b) Bolsas reutilizables

c) Artículos de carton
d) Vidrio

11) ¿En qué basa su decisión cuándo elige plásticos?
a) Marca
b) Diseño del empaque
c) Etiqueta
d) Certificaciones
e) Publicidad (lo más conocido)
f) Precio
g) Ninguno
h) El tipo de product
i) Es la presentación en la quevenden los productos

12) ¿El uso del plástico tiene consecuencias en la salud de las personas?
a) Sí
b) No
c) No se

(English)

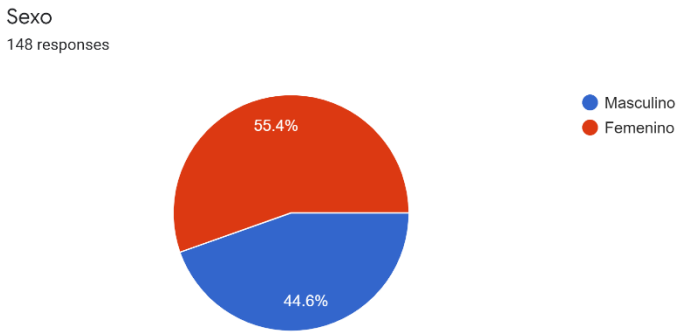
1) Sex
a) Male
b) Female
2) Age
a) 18-25
b) 26-35
c) 36-45
d) 46-55
e) 56-65
f) Más de 65
3) Province
a) Alajuela
b) Cartago
c) Guanacaste
d) Heredia
e) Limón
f) Puntarenas
4) When shopping (supermarket, personal items, other), how often do your purchases include plastic?
a) Always

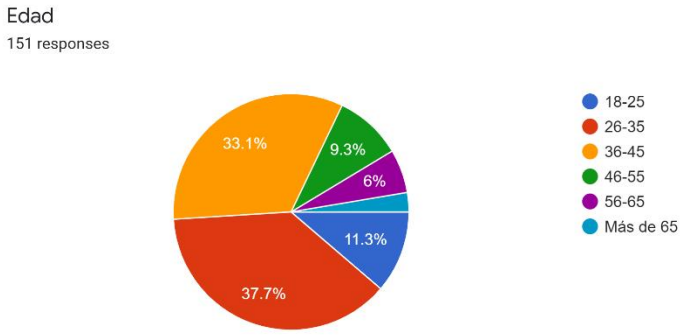
b) Almost always
c) Almost never
d) Never

5) Select all types of plastic that you know and have seen on the market.
   a) Oxo-Biodegradable
   b) Compostable
   c) Biodegradable
   d) Conventional plastic
6) Which of the following plastics do you consider to be the least harmful to the environment?
   a) OXO-Biodegradable
   b) Compostable
   c) Biodegradable
   d) conventional plastic
   e) All have the same impact on the environment
7) How do you get rid of plastic? Select all that apply.
   a) Reuse
   b) Recycle
   c) Garbage
   d) Compost
   e) Little bottle of love
8) How often do you think compostable plastics can be composted at home?
   a) Always
   b) Almost always
   c) Almost never
   d) Never
9) Do you consider bioplastics to be an environmentally safe alternative to the use of conventional plastics?
   a) Yes
   b) No
   c) Not known
10) What options do you think are best to reduce the use of plastic?
   a) Bio-Plastics
   b) Reusable bags
   c) Cardboard articles
   d) Glass
   e) Bioplastics based on cassava fiber, for example, seem to me to be a more realistic option for a material that replaces plastic and does not generate a huge environmental problem with microplastics.
11) On what do you base your decision when choosing plastics?
   a) Brand

b) Package design
c) Label
d) Certifications
e) Advertising (best known)
f) Price
g) None
h) Type of product
i) It is the presentation in which products are sold

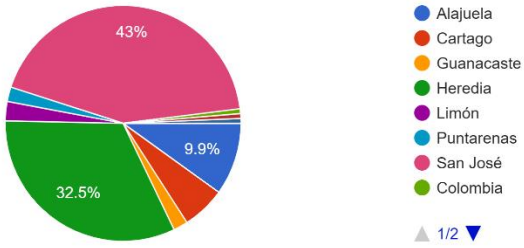
12) Does the use of plastic have consequences on people's health?
a) Yes
b) No
c) Not known





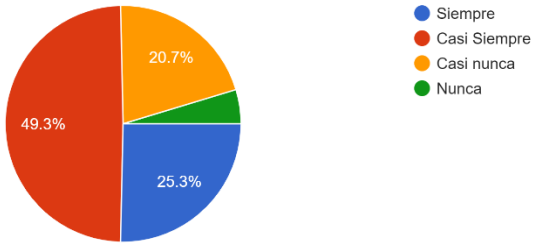
Provencia

151 responses



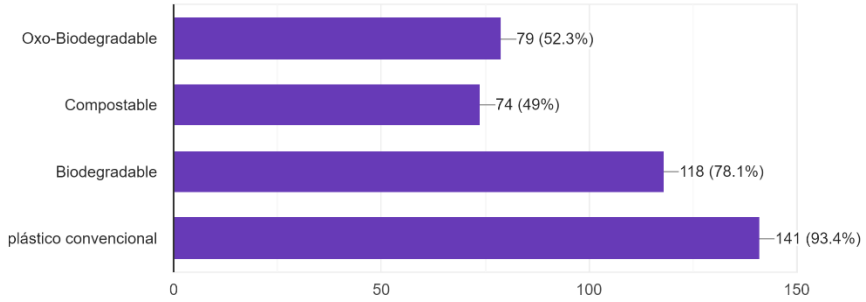
¿Al realizar sus compras (supermercado, artículos personales, otros) que tan frecuente es que las mismas incluyan plástico?

150 responses



Seleccione todos los tipos de plástico que conozca y haya visto en el mercado.

151 responses

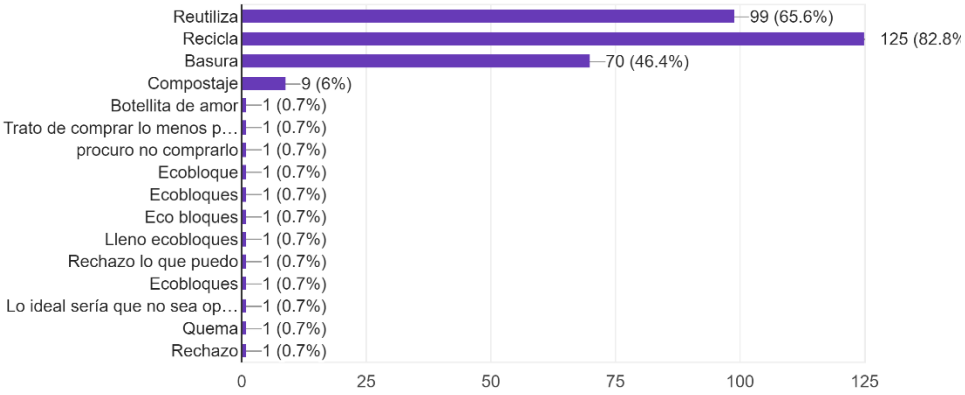


¿De los siguientes plásticos cuál considera es el menos perjudicial para el medio ambiente?

150 responses

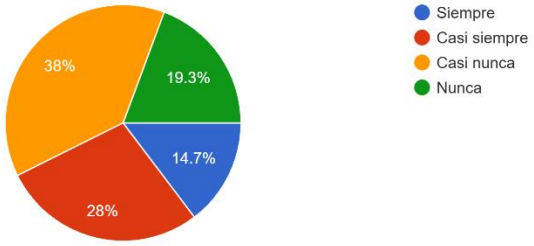
¿Cómo te deshaces del plástico? Selecciona todo lo que corresponda.

151 responses



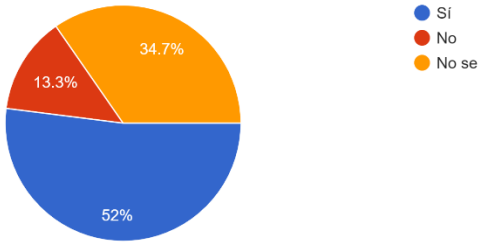
¿Con qué frecuencia cree que los plásticos compostables se pueden compostar en casa?

150 responses



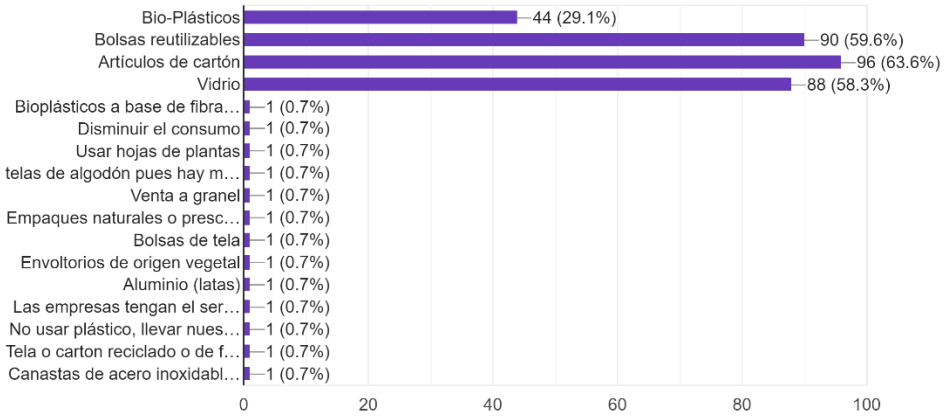
¿Considera que los bioplásticos son una alternativa ambientalmente segura al uso de plásticos convencionales?

150 responses



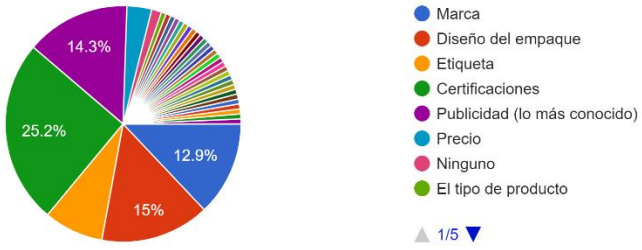
¿Cuáles opciones le parecen mejor para disminuir el uso de plástico?

151 responses



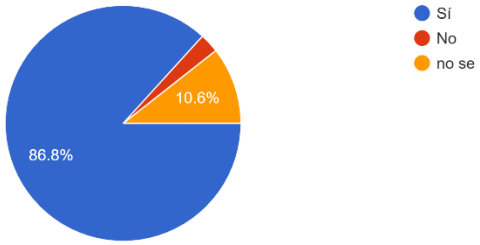
¿En qué basa su decisión cuándo elige plásticos?

147 responses



¿El uso del plástico tiene consecuencias en la salud de las personas?

151 responses



Appendix B: Interview Questions for Commercial Establishments

Appendix B contains the questions that were asked to the representatives of each of the commercial establishments. Prior to the meeting with the representatives, we sent out an email containing the questions and stated that we were willing to omit any questions if they did not wish to answer them. The email also asked for permission to record the audio and video of the meeting for future reference. When the meeting started, we confirmed with the interviewees if we were allowed to record the meetings, introduced ourselves and began asking interview questions. The questions were asked exactly how they are written below but follow up questions were asked based on the response to the original question. At the end of the meetings we asked if we could contact them in the future and thanked the interviewees for their time and contribution.

(Español)

1.) Sabemos que su establecimiento se esfuerza por ofrecer alternativas al plástico convencional, pero ¿cree que la empresa se esfuerza lo suficiente por educar a los consumidores sobre las diferencias entre los productos de plástico? ¿Qué esfuerzos se realizan? Por favor, proporcione ejemplos si es posible.

2.) Estamos entrevistando a empresas específicas que se han asociado con MarViva. ¿Qué tipo de cambios se han realizado en su establecimiento en relación con el plástico desde que se ha asociado a MarViva?

3.) ¿Sería posible que nos proporcionara una lista de los productos y tipos de plásticos que se utilizan dentro del establecimiento, por ejemplo, pajitas de polietileno número uno, vasos de polipropileno número cinco?

4.) ¿Podría facilitarnos la cantidad de plástico que se utiliza al mes en su establecimiento? ¿Existe la opción de diferentes métodos de eliminación para los clientes? En caso afirmativo, ¿con qué frecuencia diría que se desechan incorrectamente los productos de plástico?

5.) Creemos que la autoeducación es importante, ya que no se puede enseñar todo a las personas que van a la escuela. ¿Considera que la educación sobre el plástico y su eliminación debería implementarse de alguna manera durante la educación, o cree que es una cuestión en la que las personas deben educarse a sí mismas?

6.) Tenemos previsto crear un folleto o un póster que contenga información sobre la correcta eliminación de los plásticos, así como las certificaciones de los plásticos compostables o biodegradables. ¿Estaría su establecimiento interesado en dicho documento junto con otra información?

(English)

1.) We know that your establishment makes an effort to provide alternatives to conventional plastic, but do you feel that the company makes a sufficient effort to educate the consumers on

the differences between plastic products? What efforts are made? Please provide examples if possible.

2.) We are Interviewing specific companies that have been partnered with MarViva. What kind of changes have been made within your establishment dealing with plastic since it has been affiliated with MarViva?

3.) Would it be possible for you to provide us with a list of the products and types of plastics that are used within the establishment, for example, Plastic Number one Polyethylene straws, Plastic number five polypropylene cups?

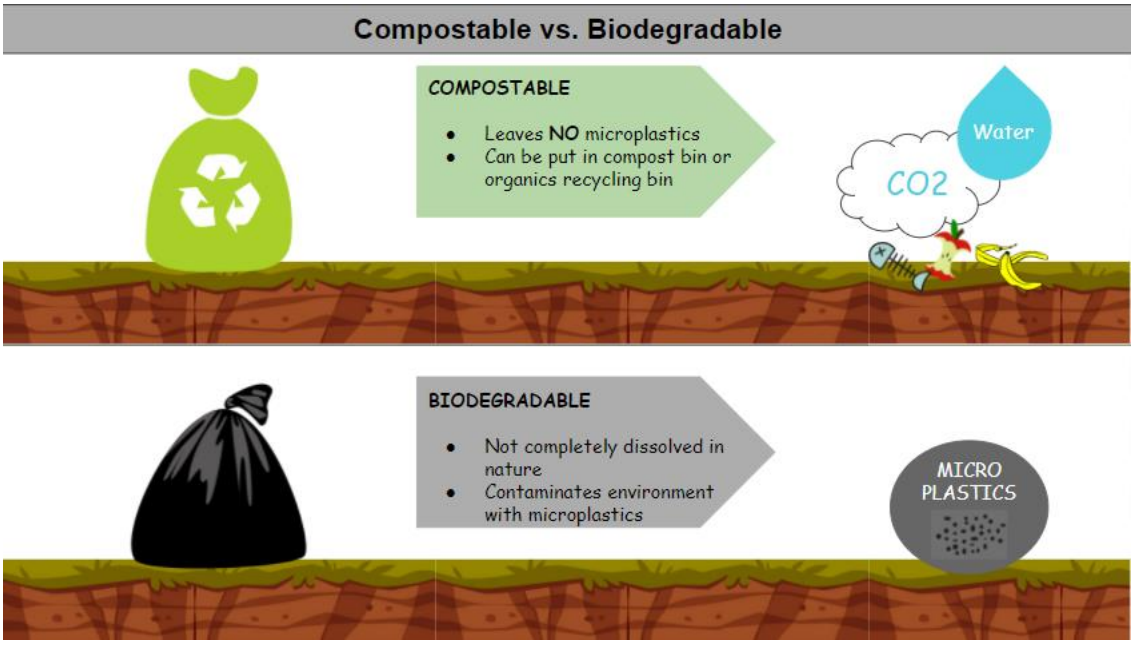
4.) Is there any way that you could provide us with the amount of plastic that is used per month at your establishment? Is there an option for different disposal methods for the customers? If so, how often would you say plastic products are incorrectly disposed of?

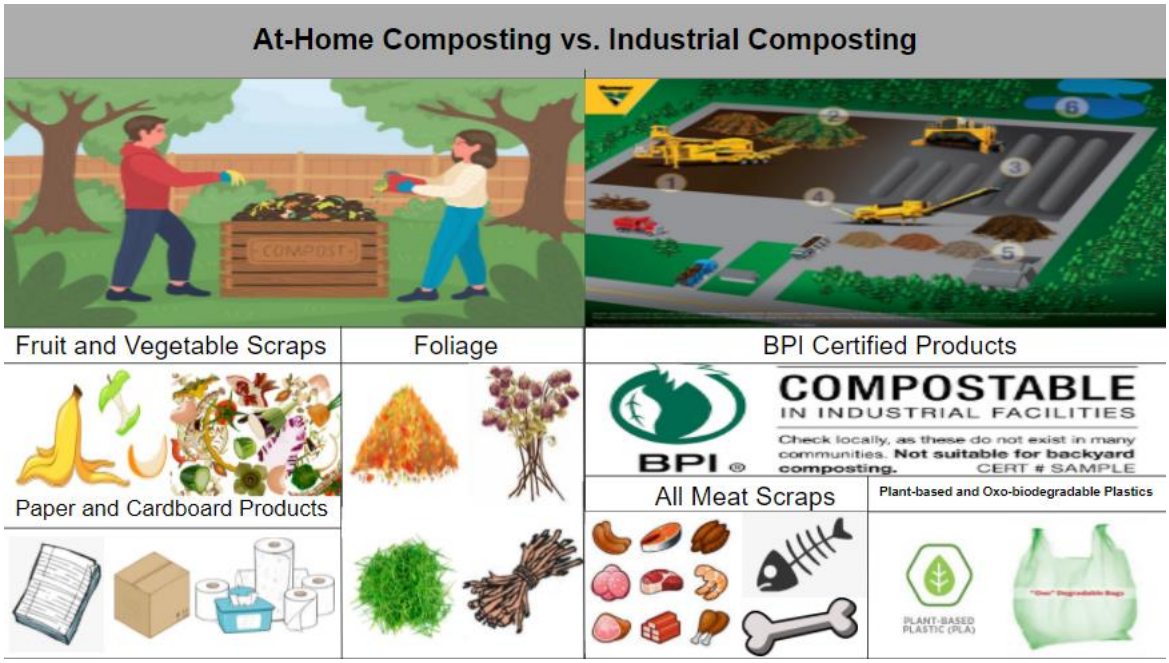
5.) We believe that self-education is important since everything cannot be taught to individuals that attend school. Do you feel that the education of plastic and its disposal should be implemented in some way during education, or do you believe that it is a matter that people should educate themselves on?

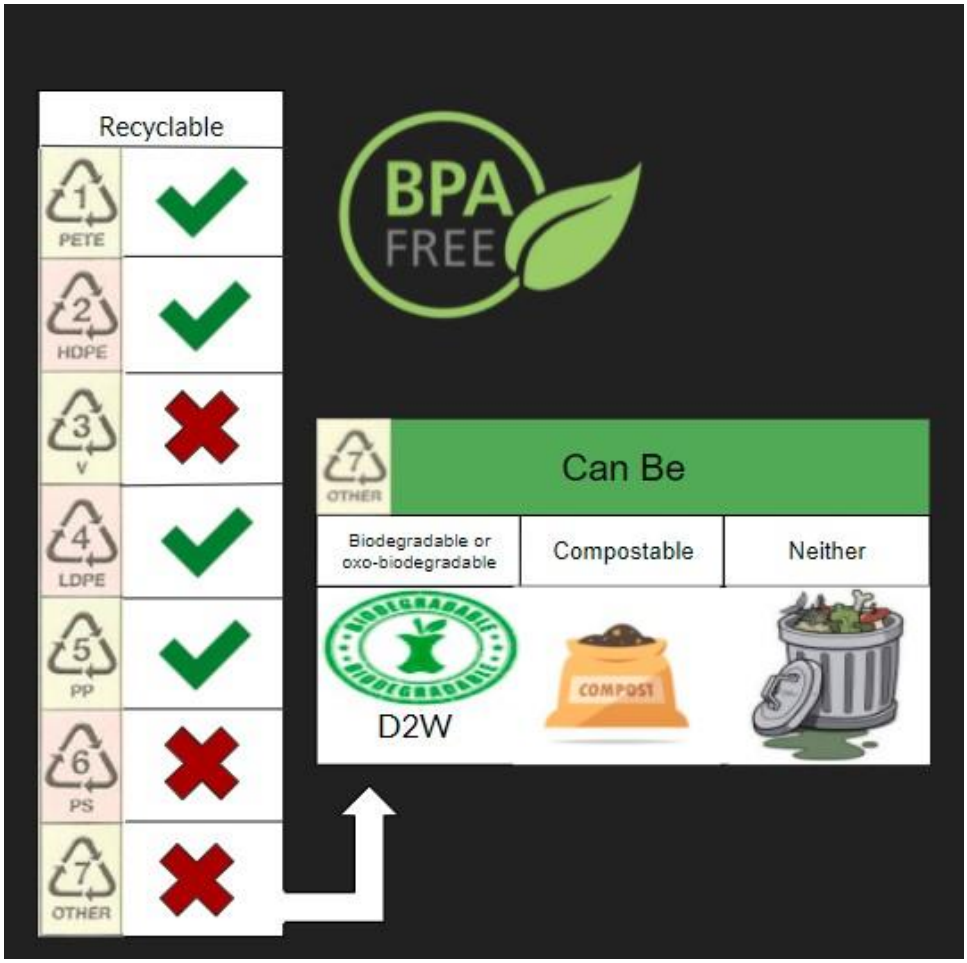
6.) We plan to create a pamphlet or a poster that contains information on the proper disposal of plastics as well as the certifications for compostable or biodegradable plastics. Would your establishment be interested in such a document along with other information?

Appendix C: Final Deliverable

Appendix C contains the infographics we made as our final deliverable for the MarViva Foundation. These infographics present easy-to-read and understand information on proper waste management that the MarViva Foundation can use for training representatives from their partnered commercial establishments. Apart from this, MarViva will be able to use these for any future projects or campaigns they work on.




At-Home Composting vs. Industrial Composting
Fruit and Vegetable Scraps
Foliage
BPI Certified Products
COMPOSTABLE
IN INDUSTRIAL FACILITIES
Check locally, as these do not exist in many communities. Not suitable for backyard composting.
CERT # SAMPLE
BPI
Paper and Cardboard Products
All Meat Scraps
Plant-based and Oxo-biodegradable Plastics
PLANT-BASED PLASTIC (PLA)


Recyclable
1 PETE
2 HDPE
3 V
4 LDPE
5 PP
6 PS
7 OTHER
BPA FREE
7 OTHER
Can Be
Biodegradable or oxo-biodegradable
Compostable
Neither
D2W
COMPOST