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A Study on the Social and the Environmental Impacts of Bottled Water & A Design Solution to Improve the User Experience of Reusable Water Bottles

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A Study on the Social and the Environmental Impacts of Bottled Water & A Design Solution to Improve the User Experience of Reusable Water Bottles

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ABSTRACT

The consumption of bottled water is likely to emerge as a global trend in the coming decades. The expansion of the bottled water industry and rapid growth of bottled water sales has caused serious concerns regarding the possible contamination of bottled water, the impact of its refuse on the environment, and the management of water resources. Some factors accelerating the sales and use of bottled water are complex and multifaceted and involve pollution, values, politics, water shortages, commercial behaviors, consumption behaviors, a widening disparity between the rich and poor within society, and the unfair distribution of resources. Any single solution is unlikely to alter the overall circumstances. However, some relevant issues may be altered or alleviated through individual effort, such as the habit of drinking bottled water. Based on the data collected through surveys and interviews, if the user experience of a reusable water bottle can be improved by increasing its portability, the consumers' intention to use reusable water bottles will increase, resulting in encouragement of the habit of drinking tap water and a decrease in the reliance on bottled water. The more that people drink tap water, then the less that bottled water consumption will negatively affect the environment, society, and the public health.

Keywords: bottled water, tap, pollutions, sustainability, portability, habit

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Preface

Like many other countries, my home city of Taipei, which is the capital of Taiwan, has been struggling with water pollution problems for a long time. Therefore, even though the authorities have declared that the tap water is examined strictly to ensure the safety and meet the drinking water standard, the public in Taiwan still do not trust the quality of tap water. I remember that when I was a child, boiling water was the most common way for most households to sterilize tap water. My mom usually put the kettle on the stove and waited until the water had boiled, and then she would open the lid and let the water simmer for at least 5 to 10 minutes to dissipate through evaporation any residual chlorine. According to a report from Taiwan's Department of Environmental Sanitation & Toxic Substance Management, this method can reduce most chlorine and trihalomethanes (THMs) in tap water. Even today, many households in Taiwan still use this method to have low-priced, clean, and safe drinking water.[1]

After I graduated from high school, I decided to go to the United States to study abroad, and hence, I had the opportunity to have direct experience of handling recyclables in this country and to learn more about issues arising from consumption of bottled water. In 2002, I left Taiwan and moved to Los Angeles County, California. Unlike many households in Taiwan, I found that people in Los Angeles rarely purified water through boiling. Many households had installed water purification systems at home or used water filter pitchers such as the "Brita" pitcher; others would drink bottled water or buy distilled water from water stores. I was someone using the latter. Purchasing water from a water store was an interesting experience for me. I had not ever seen any water stores like this when I lived in Taipei. When I walked into a water store in Rowland Heights for the first time, I saw a variety of porcelain water dispensers and reusable water bottles were orderly placed on shelves along a long wall. Near the exit of the store, there was a counter. Behind the counter, there was a very large room with a large window. Through the window, I could see a huge water purification system which looked like several stainless steel barrels, machines connected together by thick tubes. The purified distilled water was dispensed from a tap on the side of the water purification machine. Customers could either bring their own bottles or buy empty bottles at the store to fill with distilled water. I bought a five gallon reusable bottle in that store which cost $24 dollars and paid another 75 cents to fill this bottle with distilled water. During the time I lived in Southern California, buying distilled water from a water store was a relatively convenient choice for me compared to drinking boiled water.

In 2006, I transferred to UC Berkeley and rented a small bedroom in a condo in the Bay Area of Northern California. Since there was not any water stores like the ones I discovered in my Los Angeles neighborhood, I considered buying spring water from a water vending machine, which was located next to the entrances of a nearby supermarket. It cost roughly 50 cents per gallon for spring water. The price of spring water was not expensive, but I felt some doubt about its purity and quality of the water dispensed from the machine placed next to a road with dirt and mud. Since then, bottled water became a "necessity" of my own

life. Every month I purchased a pack of twenty-four, 16.9 ounce bottles of water to take to school and another five, 1 gallon bottles of water for drinking at home. It goes without saying that a large number of empty plastic disposable bottles soon accumulated in my room and became overwhelming. In the community where I lived in the Bay Area, it was not required for residents to sort trash for recycling. Residents only needed to throw away all kinds of trash into garbage containers placed in a certain area. A garbage truck would come to empty those garbage containers every morning.

In Taiwan, we have built a well-developed recycling system. It is mandatory for every household to sort garbage into six different categories and recycle. Initially, the policy was only implemented in Taipei City on January 1st, 2005, and then it was implemented effective nationwide on January 1st, 2006. The garbage trucks routinely stop at specific times and spots, five days a week to collect recycling materials and garbage. Whenever a garbage truck arrives at a collection point, it comes with three to four attendants to guide residents to place garbage and recyclable materials into the correct containers. Offenders who violate the

Household Waste Pick-up Schedule in Taipei City

Category	Description	Pickup Schedule
Flat Recyclable Materials	clothes, paper, film plastics, and clean plastic bags	Mon & Fri
Solid Recyclable Materials	bottles, containers, metal, tires, styrofoam, small electric appliances, and used motor oil recycle	Tue, Thu, and Sat
Electronic Waste	batteries, disc, cell phone, and fluorescent tube	Mon, Tue, Thu, Fri, and Sat
Cooked Food Scraps	cooked food scraps will be processed to produce pig feed	Mon, Tue, Thu, Fri, and Sat
Raw Food Scraps	raw food scraps will be processed to produce organic fertilizer	Mon, Tue, Thu, Fri, and Sat
Waste	household waste that cannot be recycled	Mon, Tue, Thu, Fri, and Sat

recycling regulations and refuse to do recycling and/or garbage classification can be fined from TWD$1200 to $6000 (or roughly USD$40 to $200). The government has also promoted a policy called "Keeping Trash off The Ground," which means that residents are not allowed to leave garbage on the ground and have to hold it while waiting for garbage trucks to pick up. These policies did draw criticism initially but ultimately gained support from the public and successfully increased the recycling rate. In 2011, the overall recycling rate in Taiwan already reached 48.8% which is higher than the United States, the United Kingdom, Japan, and other industrialized nations.[2]

Unfortunately, there was not a comprehensive recycling system like the one in Taiwan when I lived in the Bay Area. In order to deal with the massive amount of plastic waste, I found an El Cerrito Recycling Center, which was about one mile away from my residence. This recycling center basically accepted all curbside recycling materials and some hard to recycle items such as chemistry equipment, bricks, house wares, furniture, and electronic waste. I drove over and dropped off a large cardboard box full of plastic bottles at the recycling center every month. In the meanwhile, I was thinking that there should be a more effective and interactive recycling system to reduce the waste to the lowest possible level, especially when reducing waste and doing recycling had become commonplace. The lack of a complete and efficient recycling system in a city, like in El Cerrito, seems to encourage residents to throw items away rather than recycle. The experience of dealing with and recycling numerous plastic disposable bottles was also a factor that inspired me to consider the environmental impact generated by the simple behavior of drinking bottled water.

After I graduated from UC Berkeley, I applied to and was accepted by the Industrial Design Graduate School at Rochester Institute of Technology, so I moved to an apartment in Rochester, NY in 2008. Due to the troublesome experience of struggling with numerous plastic bottles in the Bay Area, I decided to use a Brita filtration pitcher instead of buying bottled water. The most basic Brita filtration pitcher costs $9.99, and a 3-pack of Brita replacement filter cartridges costs about $19.99. Each filter can last 1 to 2 months. Obviously using a filtration pitcher is much less expensive when compared to buying bottled water. After using the Brita filtration pitcher for a period of time, I found that it did really help to save both money and plastic bottles, but the filter cartridges were impossible to be recycled and could only be discarded as household trash. That also creates unnecessary plastic wastes.

Brita's filter cartridge plastic shells are made of Polypropylene (PP), which is classified as a type 5 plastic. Technically, all kind of plastics are recyclable with various temperatures and procedures to reformulate and reproduce as raw materials, but due to the market value and rate of recyclability, most local recycling centers only accept type 1 (PET) and type 2 (HDPE) plastics in the United States. The other types of plastics consequently are considered as non-recyclable. For recycling these non-recyclable plastics, residents need to contact their county's Department of Public Works or recycling centers to determine where these plastics can be accepted and recycled; otherwise, such plastics can only be buried in landfills. In addition, sorting plastics is a critical point in recycling process because plastics can only be recycled with their own kind. Mixing of different kinds of plastics

together will downgrade the value or cause contamination of recycled materials. In term of the complicated recycling situation in the United States, thousands and thousands of Brita filter cartridges are wastefully ending up either in landfills or incineration plants.

Brita Company was founded in Germany in 1966. Starting in 1992, Brita in Europe has implemented a recycling program that customers in Germany, Great Britain, Ireland, France, and Switzerland can easily return used filter cartridges by dropping them into collection bins placed in front of retail stores. All used cartridges are then shipped back to Brita's own recycling plant in Germany where all the component parts are dismantled and processed for secondary use. While Brita cartridges are systematically collected and recycled in Europe, Clorox Company, which is the sole distributor of Brita products in North America, had refused to create a recycling system similar with the one in Europe for customers to recycle used cartridges. With the rise of environmental consciousness, a wave of criticism began to grow compelling Clorox Company to undertake its social responsibility to reduce its carbon footprint and to achieve a good balance between business operations and environmental protection. In April 2008, a plastic-free pioneer, Beth Terry, decided to take action and published a petition online to urge Clorox to collect and recycle used Brita water filter cartridges. She soon collected 6,267 signatures on the petition and initiated a campaign called "Take Back The Filter" in June of 2008. The purpose of the campaign was to urge Clorox to:

1. Redesign its Brita filter cartridges so that the plastic housing can be refilled rather than discarded each time the filter is changed.
2. Provide a take-back program, such as the one that exists in Europe, so that used cartridges can be returned to the company for recycling.
3. Create a system for the cartridges to be dismantled and for the components to be recycled or reused domestically rather than sent to domestic landfills, incinerated, or shipped overseas.

Under this pressure from environmental campaign groups, Clorox Company eventually agreed to cooperate with Preserve, a company specifically producing 100% recycled household consumer goods, to launch a recycling program called Gimme 5 in early January 2009. According to a press release from Clorox Company in November 2008, "Preserve will recycle 100 percent of each Brita plastic pitcher filter casing collected. The type 5 polypropylene plastic from the casing will be used by Preserve in their line of products. The filter ingredients…will be regenerated for alternative use or converted into energy." The purpose of the Gimme 5 program is to collect type 5 plastic, which is rarely recyclable in most communities, from individuals and retail stores and to reprocess these discarded plastic products into new "green" products for sale. Consumers can either drop off any type 5 plastic products, including used Brita filters, into Preserve's Gimme 5 collection bins placed at participating cooperative stores without additional costs or mail them to the Preserve Company directly on their own paying postage costs.[3]

Although the Gimme 5 program has been seen as a positive response by Clorox Company to the environmentalist groups' demands and complaints, some disadvantages which limit the program's popularity and applicability still exist. First, other than

Whole Foods Stores, there are not many large chain stores participating in this program. People living in some regions, such as Rochester, NY, are unable to find a Gimme 5 drop box and have to mail the type 5 plastic products to Preserve Company located in Cortland, NY at their own expense. This certainly decreases the willingness of consumers to participate in this recycling program. In addition, lacking the participation of large chain stores means that there is a lack of an important platform to promote this recycling program to the public. Second, only Brita brand filter cartridges are recycled via the Gimme 5 program; other non-Brita pitcher filters are still not accepted. To amplify its influence and encourage more people to support this program, the Preserve Gimme 5 program should consider accepting other brands of filter cartridges as long as those cartridges are made of type 5 plastic.[4]

My experience of recycling in Rochester is another story. The community in which I live is similar to the one in which I lived in the Bay Area in that residents simply dump all their trash into garbage containers, and a truck routinely comes by and take it away. If residents want to recycle their goods, they must sort recyclables out, separate them, and bring them to a recycling center on their own; and while some beverage bottles and cans are collected by automatic recycling machines installed in most large supermarket chains such as Wegmans and Tops, the conditions for a thorough and successful recycling program are lacking. The appearance of these automatic recycling machines looks like a vending machine. Each machine is specifically designed to recycle either plastic bottles or beverage cans. Consumers need to insert beverage containers into an opening in the front of the machines following instructions. In order to avoid mixing different types of plastic together, caps are not recyclable and must be removed before inserting bottles. After beverage containers are inserted into the machines, the machines read the barcode printed on each container to sort the waste according to its type and also print out a voucher of the value of recyclable items which may be used to shop in stores. It is a very good idea that motivates consumers to recycle plastic bottles and beverage cans by providing store vouchers, but the problem is that not all kinds of beverage containers are accepted by the machines. Some beverage containers which are not produced by large, well-known brands in the United States are not recognized via the barcode scanning process and are rejected by the machines even though the containers are made of recyclable materials such as type 1 or type 2 plastics as well. This situation is inefficient that recycling materials are sorted by barcode rather than being entirely dependent upon the types of materials to be recycled. As a foreign student, I shopped in Taiwanese and Japanese grocery stores frequently, consequently most of the beverage containers I purchased were not accepted by these machines. Thus, although the automatic recycling machines are a convenient way to encourage recycling, it did not help me personally very much in recycling beverage containers. I am sure other outliers also prevented optimal recycling to occur in regard to other consumers as well.

Based on my observations and experience of dealing with recyclable items in several nations and various regions, I find that participating in recycling in the United States is complicated, inconvenient and heavily depends on the self-consciousness of the public and corporations. In my thinking the federal government should play an integral role in assisting the public, commercial enterprises and local authorities to better manage their resources and to establish a well-functioning recycling system at the

national level. Citizens should be encouraged to recycle as responsible citizens to attain the benefits of a sustainable lifestyle. However, the U.S. government has virtually no power over policymaking regarding recycling programs because such a power is not enumerated among the powers of Congress. The power to regulate solid waste and recycling is delegated to state governments under the U.S. Constitution. The positive aspect of this is that each state enjoys its own autonomy to manage its recycling programs and set up regulations based on different circumstances and public opinions. A negative aspect is that a state government can only do what it can afford fiscally. Consequently it is relatively difficult to build a comprehensive recycling system when a state government does not have sufficient funds to support it. Hence, lacking a convenient and well-established recycling system decreases many citizens' willingness to participate in recycling.

It may be argued that capitalism is like a monster driving people to exhaust the earth's natural resources for merely the pursuit of personal comfort and material desires. Once the resilience of the planet's ecosystem fails to resist the dramatic damage and exploitation caused by human beings, everyone will pay a very heavy price. The report, Melting Snow and Ice: A Call for Action, commissioned by Former Vice President Al Gore and Former Norwegian Minister of Foreign Affairs Jonas Gahr Støre, states that the "sea ice extent in the Arctic has shrunk by almost 40% since 1979, with the lowest amounts of ice observed in the last three summers: 2007, 2008, and 2009… An Arctic summer almost without sea ice may be expected before mid-century." The rapid loss of sea ice is one of the signs and effects of global warming and climate change. If the temperature of the earth continues to rise, most coastal and low-lying regions face the prospect of being submerged by rising oceans. Countless thousands of people will become refugees seeking to escape from the rising waters, and civilization will face the prospect of collapse when the environmental support system is completely destroyed. Now, it has become urgently necessary for every individual's responsibility to alter his or her lifestyle to one that is much more environmentally sustainable. How to avoid producing unnecessary waste and conserve more natural resources and energy would be a significant start.[5]

The United States, as one of the most wealthy and powerful countries in the world, constitutes less than 5% of the world's population but consumes about 25% of the world's fossil fuel resources, while Americans drink more bottled water than any other nations in the world. As the world's largest bottled water consumer market, Americans consume roughly the water of 1500 plastic bottles per every second and purchase 50 billion bottles of water every year. To help to reduce the amount of waste produced by such consumption and to conserve valuable resources and energy, many Americans have started to make unremitting efforts to change the situation. More than 90 schools across the country including the University of Vermont, Harvard University, and Washington University in St. Louis have already implemented bans on the sale and use of plastic water bottles on their respective university campuses. Some municipalities have also banned the sale of bottled water on public property such as the city of San Francisco, California. However, the United States is still lagging behind in recycling. Although there are some states and cities which are extraordinary with a significantly high recycling rate, the national recycling rate in the United States is stagnant at around 33 to 35 percent due to the fact that many areas do not dedicate much resources and efforts to it. According to the

statistics of the United States Environmental Protection Agency, “San Francisco now diverts 70% of its municipal solid waste and is on track to reach its goal of 75% by 2010, while the state of California diverts 58%. Minnesota has reached a 40% recycling rate and South Carolina is at 28%. But eleven states are still below 10%, and dozens of major metropolitan areas are in the single digits.” The issue of whether recycling should be mandatory or voluntary has been discussed by the public for years. People who agree with mandatory recycling laws claim that recycling is just an easy simple task. Since people in general are lazy and unaware of environmental issues, establishing a mandatory recycling program is the most practical and effective way to reduce wastes, to protect the environment, and to save the planet for future generations. Opponents who are against mandatory recycling believe that even though recycling can significantly benefit the environment, people should have the freedom to make their own decisions and should not be forced to do so by law. In addition, a number of opponents insist that recycling programs may not help to save more resources. Angela Logomasini, the director of risk and environmental policy at the Competitive Enterprise Institute, in an article published in The Wall Street Journal states that former New York Mayor Michael Bloomberg had planned to temporarily suspend the city's recycling of metal, glass, and plastic to save $57 million dollars in the 2003 city budget proposal because “the city spends about $240 per ton to "recycle" plastic, glass, and metal, while the cost of simply sending waste to landfills is about $130 per ton.” Former Mayor Bloomberg claimed that the recycling program was not saving resources but caused a waste of both money and energy. To set up and support a mandatory recycling program, consumed considerable funds, water, and labor hours to collect, sort, and process the materials. The city also needed to increase spending to convert to two set of trucks (garbage versus curbside recycling) which largely increased exhaust emissions, traffic, and wear on streets from the second set of trucks prowling for recyclables. Despite the fact that everyone recycled, much of recyclables sorting by residents still ended up in the landfill because about 40% of New York’s glass, metal, and plastic waste was not of suitable quality for recycling. "You could do a lot better things in the world with $57 million," said former Mayor Bloomberg. It is hard to judge whether former Mayor Bloomberg's point is correct, but the recycling experience in New York City realistically demonstrates the predicament of promoting mandatory recycling law. Many municipalities do not have sufficient financial resources to run a recycling program. In the meanwhile, most landfills still have considerable capacity, and the risk of posing health hazards to surrounding communities has been minimized in modern landfills. Landfilling waste is hence still the most efficient and economical disposal method in the United States.[6]

How people look upon environmental-related issues can reflect the value of how they treat the world around them. The pursuit of sustainability is not only a choice of lifestyle but also represents an essential attitude of human beings as part of the natural world to show respect and care towards the environment and other lives on the planet. When a society considers profit as the only measure to decide whether an objective is worth achieving and sustaining, it demonstrates and passes on a utilitarian, self-oriented set of values to coming generations that will increasingly lead civilization away from sustainable development and towards the risk of collapse.

When I studied at RIT, I obtained an opportunity to attend the Scandinavian Furniture Design Program in Copenhagen, Denmark during the summer of 2009 and therefore had an opportunity to experience the sustainable method of life of Danes. It is really impressive how the Danes successfully put sustainability into practice in their daily life. I remember that when I arrived in Copenhagen, it was July, which was Copenhagen's hottest month with heat waves and extremely long daylight hours. The temperature could frequently reach above 85 degrees Fahrenheit (°F) under the sunshine. Even the wind was torrid and muggy. However, many of the places, including local stores, hotels, galleries, classrooms, workshops, and my dorm room, were not equipped with air conditioning. It was hard to imagine that people in Copenhagen primarily relied on fans to help alter temperatures and air circulation during summer time when people in the United States use air conditioning almost everywhere. In addition, in the laundry room located in my dorm, I discovered a type of hydroextractor which can conserve considerable water and energy when doing laundry. The appearance of the hydroextractor looks like a stainless steel keg with a lid, and it was about 25-27 inches in height. In the beginning, I did not know what it was, and then I saw that my Danish friends dropped their sopping wet clothes into the hydroextractor prior to placing clothes into tumble dryers. After using the hydroextractor for 3-5 minutes in advance, the length of time required to use a tumble dryer could be drastically reduced from 60-90 minutes to 15-20 minutes. Though modern washing machines all have a spin cycle, when using coin operated washing machines in dorms, laundry stores, or apartments, people can only select the quantity and speed. They cannot choose to run a "spin cycle only" or set the duration of the spin cycle which they need. Therefore the "hydroextractor" machines that I observed in Copenhagen are even more helpful to reduce drying time and energy consumption. As everyone knows, a tumble dryer is one of the most energy-intensive appliances in a home and can cost as much as 23p per cycle. With approximately 85% of U.S. households owning a tumble dryer, it would significantly help to save a very considerable amount of energy if the government in the United States could promote the usage of dewatering machines like the ones in Copenhagen, especially in dorms or apartments.[7]

Copenhagen is also famous as one of the most bicycle-friendly cities in the world. The city has constructed a well-designed city bike system and cycling paths and has planned many car-free zones and slow-speed limit streets. Since the early 1960s, 18 parking lots in the downtown area have been converted into beautiful public spaces for citizens to gather, relax, and enjoy. Most streets in city have a speed limit of 30 to 40 km/h (19 to 25 mph). Some blocks in certain neighborhoods even have speed limits as low as 15 km/h (9 mph) where cars must yield to residents. Other areas are planned as shared spaces for cars, bikes, and pedestrians. Thus, unlike Americans who own an average of 2.28 vehicles per household, half of Danes do not drive and usually use bikes as their primary mode of transportation to work or school. Inge Nilsson, a project leader in the City of Copenhagen's environmental office, said that "we have a common goal of being environmental (conservationists). It is a quality of life issue." In fact, according to the UN's 2013 World Happiness Report, Danes were officially ranked as the happiest people on the planet.[7]

The lifestyle of the Danes represents a belief that efficiency and material comfort are neither the priority to pursuit of a better life nor the standard to determine the meaning of happiness. In design school, we always place great emphasis on making

things more convenient and consider that this is "progress" which is better for the future. However, this may be a false premise. If this convenience only qualifies as progress and entails widespread pollution, degradation of the environment, and the extinction of species, I do not believe that this is actual "progress" but rather regression, or even a tendency towards self-destruction. As part of the earth, harmoniously coexisting with all forms of life on the planet and constantly maintaining the ecosystem's function is the only way to lead society towards sustainable development. In brief, the most valuable wisdom that I gleaned from the trip to Copenhagen is that the beauty of simplicity can not only be applied to arts and design but also it can be practiced in people's lives with a compassionate and conscientious approach to our world.

As long as people can think about the "big picture" and slightly adjust their behavior, even a small change will affect the environment positively to a very large degree. As an enterprise, if Brita filter cartridges were not designed for single use or if Clorox Company could build a more comprehensive recycling system afterward to collect used filter cartridges, more polypropylene could be diverted from landfills, and the negative impact upon the environment caused by the wasteful disposal of Brita water filters would be largely decreased. As citizens, if everyone would participate in recycling, more valuable space in landfills would be saved, and more materials would be reintroduced into the industrial chain or reused for other purposes. As consumers, likewise, if each person could choose either sustainable or high quality, long-lasting products and avoided the purchase of disposable products in the market, it could greatly reduce both every individual's carbon footprint and prevent the unnecessary waste of precious resources. Averting unnecessary waste is much more environmentally and economically preferable from the perspective of sustainable development; for instance, declining to purchase bottled water rather than recycling plastic bottles can conserve more energy and decrease resource consumption. Indeed, more people drinking tap water instead of drinking bottled water can compel the government to pay more attention to maintaining and improving the municipal drinking water system thus ensuring the right of the poor to access clean water. Also, the over-expansion of water privatization might be curbed.[8]

Bottled water is not only one of the most common, but also one of the most redundant products in modern society. It is ironic that when billions of people living in poverty suffer from the lack of clean water access, the business of selling packaged water to the wealthy has expanded dramatically and globally over the past several decades. Although Americans' tap water ranks among the safest in the world, the demand for bottled water has still rapidly increased. According to the Beverage Marketing Corp., the total of bottled water sales reached 9.1 billion gallons of bottled water in 2011, equivalent to 29.2 gallons of bottled water per person. Translating these statistics to handy half-liter size, this comes to 222 bottles of water per person in the US, meaning that each person consumes four bottles of water every week. In 2013, the total of bottled water sales in the U.S. hit another new record high and increased to 10.09 billion gallons. The 2013 numbers show the best sales ever in the U.S. market and also the highest per-person volume. In the words of Charles Fishman, an investigative journalist and author, "Bottled water sales aren't just growing — it's fair to say they're booming." The boom in the bottled water business comes at a high environmental price. Although plastic water bottles are recyclable, approximately 86% of plastic bottles land in the garbage instead of being

recycled. Considering the fact that approximately 60 million plastic bottles are disposed of every day, it is estimated that there will be nearly 18 billion plastic bottles entered into landfills each year. Each bottle can take hundreds or even thousands of years to completely biodegrade. Bottled water has been widely accepted by the public mostly due to its convenience, but the price and consequence of convenience might be too heavy to bear.[9]

With the tremendously rapid growth of technology and ever-accelerating pace of living, creating a more efficient, convenient way of lifestyle has, it seems, become an inevitable trend in the scope of industrial design. Numerous products have emerged in the market emphasizing the words "easy," "quick," "rapid," or "single-use only" on packaging to attract consumers' attention and promote products. Though varied evidence has proven the fact that the excessive pursuit of convenience and material comfort will eventually cause the collapse of the planet's ecosystem, people have to face the fact that they can either let the situation fester or live in a mindful as well as sustainable way to move the world forward in a positive direction. Further, though disposable products in general are common in the market, industrial designers must consider whether their first priority and the goal of industrial design is to design for the favor of consumers or to design for the benefit of society as a whole. Everyone shares this planet. Only when a design can actually enhance sustainable development and social progress in either a direct or indirect way can a design benefit a society as a whole. Thus, I believe that an industrial designer in contemporary society should play the role of a navigator who undertakes the responsibility to plot a course towards a better future and then influences, inspires, and motivates consumers to advance through continuous improvements and creativity in design. With this goal in my mind, I choose to address the issue of bottled water as the topic of my thesis and hope to make my best of this endeavor to help to alleviate the bottled water problem through my proposed design and to urge more people to consider their consumption habits through my thesis. I sincerely hope that my design can help to make a small change in people's lives and make the world a little better.[10]

Chapter 1

The Effects of Bottled Water

Water is an essential element of our lives. It comes from nature and is should be free and easily obtained everywhere for everyone. However, over the past decade, since the pollution of water resources has become a serious concern and an issue worldwide, the bottled water industry has grown rapidly and expands while disparaging the purity and quality of tap water and playing upon people's fear about contamination and contagion in drinking water. According to the statistics released by the International Bottled Water Association (IBWA) in May 2011, although the overall consumption of bottled water in the United States had slightly declined in 2008 and 2009, total U.S. bottled water consumption grew 3.5% in 2010. As the world's largest consumer market for bottled water, each person in the United States drinks an average of 28.3 gallons of bottled water annually (which equals approximately 107.12 liters of bottled water). In addition the United States' bottled water industry has expanded its business to almost every major geographical region of the world.[1] According to data from the Beverage Marketing Corporation, global bottled water consumption was estimated to have already reached 53 billion gallons in 2008.[2] It is believed that global bottled water consumption is likely to continue to increase in the future. As the bottled water industry emerges to prominence globally, it also triggers significant concerns regarding the contamination of bottled water, its impact on the environment, and the management of water resources.

The Contamination of Bottled Water

By implementing clever marketing strategies, the bottled water industry convinces consumers to believe that bottled water is fresher, tastier, and healthier and is worth paying even up to 1000 times more than the cost of tap water in some markets. For example, Evian Natural Spring Water, which is a famous brand of bottled water, costs as much as $2.50 per 50.7oz ($6.28 per gallon), but the average price of U.S. municipal drinking water is only about $1.5 for 1000 gallons; thus, one gallon of municipal drinking water only cost less than a penny. Although the price of bottled water is already higher than the price of gasoline, many researches and experts have suggested that bottled water is no safer and better than tap water. The expensive price does not reflect on the quality of bottled water. Behind the sophisticated advertisements and brand images, bottled water actually sales a lifestyle, a fashion, constitutes a trend, and is an illusion and is proven to not be pristine water.

Bottled water enterprises are most criticized for the use of polyethylene terephthalate (PET) for bottling water. PET is an engineered thermoplastic. It was invented in 1941 by British chemists John Rex Whinfield and James Tennant Dickson.[3] It is resistant to heat, mineral oils, solvents, and acids and is a superb gas barrier. Also, it is durable, strong, light-weight, impact resistant, naturally transparent, and entirely recyclable. (See Table 1-1.) The most imperative characteristic of PET is that most researchers suggest that PET does not leach chemicals into food and beverage under normal conditions of use. These characteristics make PET ideal to be a safe and cost-effective choice for food and beverage packaging in the mass manufacturing process.[4]

However, the debate regarding the safety of PET packaging is still continuing as some experts warn that PET plastic may leach antimony (Sb) into water when it is used as containers for bottling water. Antimony trioxide (Sb2O3) is used as the single most important catalyst in the manufacture of PET by most bottled water sellers. It is a white metallic element that in small doses can cause nausea, dizziness, illness, and depression. When ingesting large doses of antimony, it can cause violent vomiting and even death. According to the United States Environmental Protection Agency (USEPA), some people who drink water containing antimony well in excess of the maximum contaminant level (MCL) of 6 ppb or 0.006 mg/L for many years could experience an increase in blood cholesterol and a decrease in blood sugar. Antimony has also been linked to heart damage, cancer, and SIDS (Sudden Infant Death Syndrome). In 2006, Dr. William Shotyk, who is a Canadian scientist and currently professor and director of

Table 1-1. Characteristics of PET

1	Semi-rigid to rigid depending on wall thickness
2	Natural color: clear and transparent
3	Good resistance to heat, mineral oils, acids
4	Good gas barrier (particularly against oxygen and carbon dioxide)
5	Good alcohol and solvent barrier
6	Good stress crack and impact resistance at room temperature and above
7	Fair moisture barrier
8	Food compatible
9	Good moldability
10	Completely recyclable
11	Can be sterilized with EtO (ethylene oxide) or gamma radiation
12	Poor chemical barrier for strong acids and bases

Source: See Endnote 4.

the Institute of Environmental Geochemistry in Germany, released a study measuring antimony concentrations in 132 brands of bottled water from 26 countries that indicated that bottled water can be contaminated with antimony that is constantly leaching from PET plastic into the water. In general, PET contains several hundred mg/kg of Sb, compared with less than 1 mg/kg Sb which is found occurring naturally in most rocks and soils at the surface of the earth. Dr. Shotyk and his team measured Sb in groundwater from a rural region of Canada. The pristine groundwater was found to have antimony levels of only two parts per trillion (ppt) of Sb, but samples of bottled waters were typically found to have a few hundred times greater the level of antimony in groundwater. For comparison, Dr. Shotyk collected samples from three German brands of water available in both glass bottles and PET containers, and the results showed that water bottled in PET containers had up to 30 times more Sb. In the final test of the contamination hypothesis, the sample from a commercial source in Germany was found to have antimony levels of only four ppt of Sb before bottling, yet this same brand of water in PET bottles was measured to contain 360 ppt. The longer the water was stored in plastic bottles, the higher the concentration of antimony was measured. When samples were stored at room temperature for six months, the antimony level of many brands' bottled water reached levels near 2000 ppt, which is the limit for antimony in drinking water in Japan. "This doesn't mean there is a clear health risk," said Dr. Shotyk, "but I would say it's something to think about." According to Larry Wade of the Ottawa Water Study/Action Committee, "If people knew that after only six months of storage, a chemical that may be hazardous to human health could reach levels in this water unacceptable in countries like Japan, they would likely think twice about relying on bottled water."[5]

Another study released in the United States, which was conducted by the Department of Civil and Environmental Engineering at Arizona State University in 2008, reports that elevated temperatures could increase antimony concentrations leaching from PET containers. Samples from nine commercially available brands of bottled water in the southwestern U.S. (Arizona) were tested. That study showed that when bottled water was stored at 22 degree C, samples were measured to contain only about 0.095 to 0.521 parts per billion (ppb), which was well below the maximum contaminant level (MCL) set by United States Environmental Protection Agency at 6 ppb. However, when samples were stored at high temperature, the statistics had significant differences. Under exposure temperatures of 60, 65, 70, 75, 80, and 85 degrees C, the antimony concentration in samples could exceed the 6 ppb MCL after 176, 38, 12, 4.7, 2.3, and 1.3 days. The result demonstrates that consumers should take into consideration elevated storage temperatures to avoid potential leaching of chemicals from PET bottles, especially in some environments exposed to extremely high temperature.[6]

On January 5th, 2011, the Environmental Working Group (EWG) issued a report criticizing and documenting the failure of the bottled water industry to provide complete information about the water's sources, the method of purification, and any chemical pollutants that leach from plastic containers or remain after purification treatments.7 To face all the doubts and questions about any potential harmful contamination in bottled water, the International Bottled Water Association (IBWA) immediately released a response to the EWG report on January 26, 2011 and stoutly claimed that bottled water is a safe, healthy

beverage alternative on the market. IBWA also emphasized that the quality of products be it water itself or its containers, are comprehensively regulated under both federal and state laws. Regarding the safety and regulation of bottled water, IBWA's response was as follows:

Bottled water is a safe, healthy, and convenient packaged food product, which is comprehensively regulated at both the federal and state level. At the federal level, bottled water must comply with the Federal Food, Drug, and Cosmetic Act (FFDCA) (21 U.S.C. §§ 301 et seq.) and several parts of Title 21 of the Code of Federal Regulations. Section 410 of FFDCA requires that the Food and Drug Administration's (FDA) bottled water regulations be as stringent and as protective of the public health as the U.S. Environmental Protection Agency's (EPA) tap water standards.[8]

Though bottled water is not an unregulated product, the controversy comes rather from whether or not bottled water is a well regulated product under the supervision and control of government. As per the statement of IBWA, bottled water is regulated under the U.S. Food and Drug Administration (FDA) because it is considered a food product sold in individual packages which explains why consumers can find a "Nutrition Label" on bottled water which redundantly indicates that water contains no calories, no protein, no fat, no carbohydrates, no sodium, and no sugars. On the premise of protecting public health, the standards of the FDA for bottled water are supposed to be as effective as the regulations of the Environmental Protection Agency (EPA) are regarding public drinking water. However, the different enforcing authorities and divergent procedures found between FDA and EPA create ambiguities and increase the potential risks of drinking bottled water.[9]

Any quality assurance of water quality can only rely on the frequency of the inspections, the impartiality of testing, and the effectiveness of practice. The companies producing bottled water assert that they can better control water quality than the authorities regulating tap water can and provide purer and safer water compared with tap water, but this is not true. The significant differences of inspection standards and operating procedures between the FDA and the EPA make bottled water no safer than tap water, or even less safe.

A. The Frequency of Inspections

The quality and safety of municipal water and bottled water can be analyzed through the frequency of inspections for chemical contaminants, cryptosporidium or giardia, and caliform bacteria. (See Table 1-2.)

Chemical Contaminants

According to the website of the EPA, "The chemical contaminants are regulated in phases, which are collectively referred to as the Chemical Phase Rules. These rules regulate over 65 contaminants in three contaminant groups: Inorganic Contaminants (IOCs), Volatile Organic Contaminants (VOCs), and Synthetic Organic Contaminants (SOCs)." Depending on various types, sizes, and water sources for the public water system, the EPA determines which chemical contaminants are important to monitor for the system. The cities tested by the EPA must be tested at least once quarterly for many chemical contaminants. However, unlike the EPA's rules, bottled water must only be tested only once a year.10 Even when the water is contaminated, the results of contaminant testing on that water need not be disclosed to the public. Consumers never know what is actually contained in bottled water for drinking and there exists a significant likelihood of consumers drinking chemically contaminated water to some degree. In 2008, laboratory tests conducted for the Environmental Working Group (EWG) revealed that a mixture of 38 different pollutants from 10 popular bottled water brands in the United States were found. (see Table 1-3., Table 1-4., Table 1-5., Table 1-6., and Table 1-7.) Chemical contaminants in the report are categorized into water treatment chemicals, pollutants from fertilizers, drugs, and synthetic chemicals. Drinking water containing certain amounts of chemical contaminants repeatedly could cause acute and chronic health effects. These tests conducted for the EWG strongly prove that the FDA's regulation is not strict enough and creates a loophole which threatens the public health.[11]

Table 1-2. Frequency of Inspections

	Municipal Water	Bottled Water
Chemical Contaminants	The EPA requests that cities generally must test at least once a quarter for many chemical contaminants.	Generally must test only once a year.
Cryptosporidium or Giardia	Most public water systems must inspect water for Cryptosporidium or Giardia	Not Requested
Coliform Bacteria	system serving ≥2.5 million: 420 times per month system serving < 50000: 60 times per month system serving < 1000: quarterly at least	Only requested to test water for general coliforms once a week

Source: See Endnote 10.

Table 1-3. Disinfectant byproducts that were Found in 4 Brands			
Water Treatment Chemical			
Chemical	**Number of Brands**	**Range of Detections, ppb***	**Average of Detected Values, ppb***
Total Trihalomethanes	4	4.4 - 37	21
Chloroform	4	3.8 - 31	15
Bromodichloromethane	4	0.6-13	4.5
Bromoform	1	0.8	0.8
Chlorodibromomethane	1	3.7 - 8.2	5.4
Haloacetic Acids			
Dichloroacetic acid	2	2	2
Trichloroacetic acid	1	2	2

*ppb = parts per billion (micrograms per liter)
Source: Environmental Working Group.

Table 1-4. Fluoride Was Found in 5 Brands			
Water Treatment Chemical			
Chemical	**Number of Brands**	**Range of Detections, ppm***	**Average of Detected Values, ppm***
Fluoride	5	0.15-1.07	0.67

*ppm = parts per million (micrograms per liter, mg/L)
Source: Environmental Working Group.

Table 1-5. Pollutants from Fertilizers Found in 6 Brands			
Fertilizer Pollution			
Chemical	**Number of Brands**	**Range of Detections, ppm***	**Average of Detected Values, ppm***
Nitrate (Nitrogen as N)	6	0.1 - 1.7	0.51
Ammonia (Nitrogen as N)	1	0.12	0.12

*ppm = parts per million (micrograms per liter, mg/L)
Source: Environmental Working Group.

Table 1-6. Drugs and Drug Breakdown Products Were Found in 3 Brands			
Drugs			
Chemical	**Number of Brands**	**Range of Detections, ppt***	**Average of Detected Values, ppt***
Acetaminophen	2	1.1 - 1.3	1.2
Caffeine	1	51	51
1,7-Dimethylxanthine (breakdown product of caffeine)	1	10	10

*ppt = parts per trillion (nanograms per liter)
Source: Environmental Working Group.

Table 1-7. Synthetic Chemicals Were Found in 9 Brands			
Synthetic Chemical Used In Chemical Industry And Plastic Production			
Chemical	**Number of Brands**	**Range of Detections, ppb***	**Average of Detected Values, ppb***
Acetaldehyde	4	0.6 - 36	9.7
Hexane	4	0.2 - 0.8	0.55
Toluene	4	0.5 - 2.9	1.5
2-Methyl-1-propene	3	0.3 - 0.6	0.47
3-Methyl pentane	3	0.3 - 0.8	0.47
Isobutane	3	2.3 - 13.3	7

Methylcyclopentane	3	0.7 - 1.3	0.9
Octane	3	0.2 - 4	1.7
3-Methyl heptane	2	0.4 - 0.6	0.5
Cyclohexane	2	0.4 - 1.3	0.73
Decane	2	0.6 - 1.5	0.93
Heptadecane	2	0.3 - 1.2	0.75
(Z)-13-Docosenamide	1	1.2	1.2
1-Hexene	1	0.2	0.2
Hexadecanamide	1	0.7	0.7
Hexadecane	1	0.5	0.5
Methyl cyclopentane	1	1.3	1.3
Naphthalene	1	0.3	0.3
Nonadecane	1	0.4	0.4
Nonanoic acid	1	0.4	0.4
o-Hydroxybiphenyl	1	1.0	1.0
Tetrachloroethene	1	0.5	0.5

**ppb = parts per billion (micrograms per liter)
Source: Environmental Working Group.

Coliform Bacteria

The EPA has a special regulation called the "Total Coliform Rule" to prevent the existence of Coliform Bacterial in public drinking water. All public water systems are required to monitor tap water for total coliform. Systems serving 2.5 million customers or more are required to test 420 times per month. Systems serving fewer than 50,000 customers must test 60 times per month. Small systems serving fewer than 1,000 people must test quarterly at least. In the inspection process, if any coliforms are detected, the water has to be tested repeatedly for the more dangerous fecal coliform called Escherichia coli (E. coli). Once fecal coliform are detected, it is mandated by the EPA's regulations to immediately notify the relevant state government by the end of that day, to disinfect the tap water system, and to release a public notification to the public on the same day.9 Nevertheless, according to the website of the FDA, the "FDA has established specific regulations for bottled water in Title 21 of the Code of Federal Regulations (21 CFR)… that establish allowable levels for chemical, physical, microbial, and radiological contaminants in bottled water." The regulations of the FDA only require that bottled water enterprises test water for general coliforms once a week, and a certain amount of any type of coliform organisms is legally allowed to be contained in bottled water. Even if coliform organisms are found in water, there is no additional action required to retest for the existence of any dangerous kind of fecal coliform.[12]

Cryptosporidium or Giardia

As detailed just prior, bottled water companies claim that spring water is more pure and natural than municipal water, but it does not mean that spring water is any safer than tap water. Peter H. Gleick states in his book entitled Bottled & Sold that "Municipal water, after all, is already considered safe to drink under the EPA's regulation. And as for spring water, there are loopholes in U.S. regulations that open the door to contamination by viruses and other pathogenic organisms." Cryptosporidium and Giardia are two common water pathogens which can cause diarrhea and other intestinal problems. Most public water systems must be inspected for Cryptosporidium or Giardia, but the bottled water industry is not required to do this under FDA rules. Spring water without appropriate treatment processes and regular inspection can increase the risk of contamination of drinking water.[9]

B. The Impartiality of Testing

People in the United States rely on the FDA as their first defense to protect their health and expect that examinations and inspections for the quality and safety of bottled water are performed conscientiously and carefully by the FDA, but in reality, most testing for possible contaminations only rely on the bottled water producers themselves. According to the article Bottled Water Regulation and the FDA, "As with other types of food, the FDA periodically collects and analyzes samples of bottled water… Some

samples are collected during inspections if the inspector's observations warrant collection to test for contaminants or if the bottled water facility has a previous history of contamination. Other samples are collected in response to trade or consumer complaints." Although the FDA may operate the inspection and test the quality of water in certain circumstances, it rarely happens because bottled water is considered to have a "good quality" status per the FDA's records. Generally the FDA assigns the authority to states to inspect, sample, and approve the water sources and the finished products. Bottlers are required under laws to maintain testing records for two years and to show these to government inspectors at reasonable times, but the test results, which have all been done by the bottlers themselves, are not required to be open to the public, not sent to any federal office, or even be confirmed by the FDA laboratories independently. The FDA's standards for the bottled water industry basically are built on the assumption that bottled water is totally safe, and is lacking comprehensive regulations and strict enforcement. Basically anything could be going on given this total lack of oversight. The "good record" of bottled water may actually only reflect the FDA's lack of knowledge to what is actually inside each bottle.[13]

C. The Effectiveness of Practice

Under the regulations of the EPA, it is mandatory that local water treatment plants provide a detailed report to city residents which include any tap water's source, the results of any examinations, and even the contaminant level violations, but bottled water companies are under no such oversight from the FDA. When any contamination is discovered in tap water, the EPA requires water agencies to report it to government immediately, notify the public, and correct the problem immediately. Nevertheless, when bottled water companies find any contamination in water, the procedure is entirely different. By the FDA's standards, bottlers must only take actions to "remove or reduce" found contamination, but there is no obligation upon bottlers to promptly report problems to the government or to notify the public about what they have detected. Most egregious is the fact that the FDA is only authorized under laws to order a recall when a medical device, human tissue products, or contaminated infant formula may cause a risk to human health. In general, the FDA can request a company to recall contaminated products such contaminated bottled water. If the company refuses that request, the FDA can then pursue legal action and ask a court to order the company to recall the contaminated products. The procedure for recalling contaminated products usually takes a very long period of time and is entirely insufficient to protect the public health properly and in a timely manner.[9]

Another surprising truth is that only about 30 to 40 percent of bottled water products are protected and covered under these FDA standards. The FDA regulations only apply to food products sold via "interstate commerce." Therefore bottled water sold in the same state as which it is produced may be sold in stores without any regulation or water testing. This loophole remains allowing about 60 to 70 percent of all bottled water to go unexamined and unregulated and leaves the responsibility and obligation to the states themselves to guard the quality and safety of bottled water. Some states have bottled water rules, but

some states do not regulate bottled water at all.9 According to the Natural Resource Defense Council (NRDC), nearly one out of five states does not regulate bottled water. For states that regulate bottled water, the policies may be too weak to ensure bottled water quality, or state governments may lack enough funds and resources to enforce the policies. Even if bottled water is sold across state borders and thus covered by the FDA' standards, these standards are far weaker than the EPA's standards that apply to tap water in so many ways.[14]

Debate regarding the safety of bottled water is thus still ongoing. The safety of the public can be ensured only if all the results of tests and inspections are transparent to the public. The public has the right to know what a bottle of water that they buy contains, especially after paying a thousand times the price of their tap water. Even so, bottled water will be no safer than tap water unless the system regulating bottled water is made stricter and more comprehensive.

The Impact of Bottled Water Consumption on the Environment

In Plan B 3.0: Mobilizing to Save Civilization, Lester R. Brown, the founder and president of the Earth Policy Institute, points out the challenges that human beings must face and deal with in modern society, saying "Today, we are an oil-based civilization, one that is totally dependent on a resource whose production will soon be falling. Since 1981, the quantity of oil extracted has exceeded new discoveries by an ever-widening margin. In 2006, the world pumped 31 billion barrels of oil but discovered fewer than 9 billion barrels of new oil. World reserves of conventional oil are in a free fall, dropping every year."[15] In 1956, a geoscientist, M. King Hubert, proposed his Peak Oil Theory to the American Petroleum Institute and predicted that the United States would reach its peak oil production between the late 1960's and the early 1970's. The theory is that oil production will inevitably reach it maximum and then begin a downward slope of decline. In 1970, Hubert's theory was proven correct when the United States' oil production first began to decrease as it has continued to do since that time. Nowadays, many scientists and experts endeavor to find out when the world's peak oil production will occur. In a press release by Cambridge Energy Research Associates (CERA) in 2008, it is reported that "the aggregate global decline rate for fields currently in production is approximately 4.5 percent per year, and the annual field decline rates are not increasing with time." Thus, based on this research, experts in CERA believe that there is no near-term world peak oil. Although this analysis of CERA represents a basis of confidence in the future availability of oil, the global 4.5% decline rate still indicates that the world is losing the equivalent of nearly 4 million barrels of oil per day. To prevent the complete exhaustion of natural resources and the collapse of civilization, the world's citizens need to put forth an effort to transform the global economy into a sustainable one.[16]

As awareness of the need for energy conservation and carbon-reduction arises, the energy consumed by bottled water industries in nations globally is becoming an issue of broad concern. According to the statistics compiled by the Earth Policy Institute in 2006, manufacturing the nearly 29 billion plastic bottles used to package water in the United States consumes the

equivalent of more than 17 million barrels of oil. To include the energy consumed for the whole production and sales process such as filling the bottles with water, hauling it long distances to market, and storing it in refrigeration, the total demand for bottled water industries in the United States alone can consume roughly 50 million barrels of oil per year. That is enough to fuel 3 million cars for one year. If everyone would drink as much bottled water as Americans do, the world would consume more than 1 billion barrels of oil in order to produce approximately 650 billion bottles. Though the whole world faces an energy crisis, bottle water industries globally continue to consume valuable natural resources, oil, to produce and sell clean water which arguably should be free for all. Obviously, the existence of bottled water industries is one factor accelerating the exploitation of natural resources.[17]

Other than wasteful and irresponsible consumption of energy, the single-use design of bottled water is another factor to blame for damaging the environment. Although the International Bottled Water Association (IBWA) claims that PET is a safe food contact material according to federal regulations and permitted to be used for food and beverage packaging for both single and repeated use, disposable containers made of PET actually are not suitable for long-term use because it is not capable of withstanding hot temperatures over 140 degrees. It means that the disposable PET containers cannot be placed in dishwashers or be sanitized by heat; otherwise, the PET containers have a high likelihood of deformation and leaching of toxic chemicals. The narrow-neck design increases the difficulty to clean the inner surface of bottles, so bacteria may build up on niches of bottles. In fact, the bottled water containers with thin sidewalls and narrow mouths are designed for single-use only on purpose due to economic considerations. To deal with the huge amount of plastic bottles intentionally produced to be thrown away, ethically, industry ought to make efforts to build a more effective and comprehensive recycling system to encourage recycling. Unfortunately, the reality is that they take no social responsibility for this and leave it up to government. Every year around 2.7 million tons of plastic are used worldwide to produce disposable bottled water containers, and 4 out of 5 plastic water bottles end up in landfills rather than recycling centers. These discarded bottles occupy a large volume of space in landfills. Plastic bottles buried in landfills can take up to 1000 years to biodegrade and may leak toxic additives such as phthalates or antimony into the groundwater. Some consumers drink bottled water because they are afraid of the potential pollution in tap water and believe that bottled water is cleaner and purer. Ironically, the bottled water containers which they throw away can lead to more pollution affecting the quality of groundwater and the balance of nature.[18]

The FDA has established guidelines to regulate this industry entitled Standards of Identity to classify bottled water into different categories in Title 21 of the Code of Federal Regulations (21 CFR) 165.110(a)(2):

*1. **Artesian Water**: The name of water from a well tapping a confined aquifer in which the water level stands at some height above the top of the aquifer is "artesian water" or "artesian well water."*
*2. **Ground Water**: The name of water from a subsurface saturated zone that is under a pressure equal to or greater than atmospheric pressure is "ground water."*

*3. **Mineral Water**: The name of water containing not less than 250 parts per million (ppm) total dissolved solids (TDS), coming from a source tapped at one or more bore holes or springs, originating from a geologically and physically protected underground water source, may be "mineral water." Mineral water shall be distinguished from other types of water by its constant level and relative proportions of minerals and trace elements at the point of emergence from the source, due account being taken of the cycles of natural fluctuations. No minerals may be added to this water.*
*4. **Purified Water**: The name of water that has been produced by distillation, deionization, reverse osmosis, or other suitable processes and that meets the definition of "purified water" in the United States Pharmacopeia, 23d Revision, January 1, 1995, may be "purified water" or "demineralized water." Alternatively, the water may be called "deionized water", "distilled water", or "reverse osmosis water".*
*5. **Sparkling Bottled Water**: The name of water that, after treatment and possible replacement of carbon dioxide, contains the same amount of carbon dioxide from the source that it had at emergence from the source may be "sparkling bottled water."*
*6. **Spring Water**: The name of water derived from an underground formation from which water flows naturally to the surface of the earth may be "spring water." Spring water shall be collected only at the spring or through a bore hole tapping the underground formation feeding the spring. There shall be a natural force causing the water to flow to the surface through a natural orifice. The location of the spring shall be identified. Spring water collected with the use of an external force shall be from the same underground stratum as the spring, as shown by a measurable hydraulic connection using a hydrogeologically valid method between the bore hole and the natural spring, and shall have all the physical properties, before treatment, and be of the same composition and quality, as the water that flows naturally to the surface of the earth. If spring water is collected with the use of an external force, water must continue to flow naturally to the surface of the earth through the spring's natural orifice. Plants shall demonstrate, on request, to appropriate regulatory officials, using a hydrogeologically valid method that an appropriate hydraulic connection exists between the natural orifice of the spring and the bore hole.*
*7. **Sterilized Water**: The name of water that meets the requirements under "Sterility Tests" in the United States Pharmacopeia, 23d Revision, January 1, 1995, may be "sterile water" or "sterilized water."*
*8. **Well Water**: The name of water from a hole bored, drilled, or otherwise constructed in the ground which taps the water of an aquifer may be "well water."*[19]

Although the FDA sorts bottled water into eight different categories, bottled water can also basically be considered only to come from two types of sources: municipal water and underground wells or springs. According to the website of the Natural Resources Defense Council (NRDC), "An estimated 25 percent or more of bottled water is really just tap water in a bottle - sometimes further treated, sometimes not." Currently on the market, many brands of bottled water including famous brands such as Dasani (Coca-Cola) and Aquafina (Pepsi) are just selling municipal water. The FDA requires that these bottles of water sold to indicate this on their labels such as "from a municipal source" or "from a community water system." However, if water from municipal sources has

undergone a purification process like distillation, deionization, or reverse osmosis, it can be legally defined as "purified water" and does not need to indicate that the water is actually derived from a municipal source. Although bottling and selling of tap water to the public at exorbitant price is an undeniable fact, the IBWA has argued that "purified bottled water is not just tap water in a bottle" because the water has undergone several specialized treatments and processes to ensure the taste and quality as a finished water product. The remaining brands of bottled water sold on the market are mostly obtained from approved underground sources and labeled as "spring water." Some consumers specifically prefer and choose "spring water" because they assume that it is more natural and thus protected from pollutants compared with surface water. In point of fact, water obtained from such natural sources is not guaranteed to have any such quality, but the high demand for spring water has already negatively influenced the groundwater level and the ecosystem.[20]

Groundwater is a valuable natural resource and comprises about 95% of the world's freshwater. Surface water, lakes, and rivers only comprise 3% of the world's freshwater. When groundwater reaches the surface through natural pathways, it becomes springs and wells. Although groundwater is not as vulnerable as surface water which is more exposed to pollutants, it can still be contaminated by pollutants and hazardous substances that seep into the ground from the earth's surface. Since consumers usually have the misconception that "spring water" is purer to drink and is protected from the contaminations coming from the earth's surface, the demand for spring water has increased in the marketplace. Per the FDA's regulations, in order to use the term "spring water," bottlers are required to derive the water from a spring or from groundwater or a well that is hydrologically connected to a spring. So bottled water companies have built more and more bottling plants nearby watersheds and pumped groundwater from aquifers and wells for commercial withdrawals. The use of withdrawn groundwater is dedicated to irrigation for almost 70 percent of the entire world's groundwater usage, and the rest is utilized for supplying businesses, industries, or domestic uses. The reservoirs of groundwater can be naturally replenished or recharged by rainfall, snow melt, and infiltration from surface water features. When groundwater is excessively withdrawn in excess of the rate at which it can be recharged by natural processes, the groundwater level can fall and lead to water shortages for agriculture. Environmentalists and many communities have started to have grave concerns that the global expansion of the bottled water industry and the existence of large-scale bottling plants may negatively impact local ecological environments and significantly influence the conditions of rivers, streams, and wetlands.[21]

To respond to these grave concerns about the environmental impact of groundwater withdrawals, in 2004, the bottled water industry commissioned a research study with the purpose of seeking scientific evidence to prove that groundwater withdrawals for bottled water production is too negligible to impact the renewal of groundwater resources. That research was funded by the Drinking Water Research Foundation (DWRF), which was established by members of the bottled water industry and partially supported by the IBWA. That study concludes that "Annual bottled water production accounts for less than 2/100 of one percent (0.02%) of the total groundwater withdrawn in the United States each year. Additionally, based on information gathered in the DWRF study, in 2001, 87% of the water withdrawn by bottled water companies, on average, was actually bottled

for consumption by humans, so the bottling process is a very efficient one." This research has not passed any peer review for scientific publication and has not been published in any research journal, but the bottled water industry makes claims based upon and cites the results of the research regularly as evidence to ignore all voices of concerns regarding excessive groundwater withdrawals by its own members. What the DWRF's research does not reveal through the report is that the groundwater withdrawn by bottled water enterprises may not be relevant to the total amount of groundwater in the United States overall but can be considerable in regional areas and individual watersheds. As pointed out by Peter H. Gleick, who is co-founder and president of the Pacific Institute in Oakland, California, "When a bottled water plant is taking only a small part of the flows in a watershed, the impact can be modest, or even barely noticeable. But if a bottled water plant takes a significant fraction of the flows of water in a water shed, the impact can be large. And the impact is never zero." Before building a bottling plant, the enterprise should evaluate and analyze a sustainable water extraction amount, but these enterprises ignore the potential influence on the groundwater flow system and rarely undertake the social responsibility to analytically evaluate the impact in a scientifically defensible way. In addition, setting a standard to restrict the use of groundwater withdrawals is important and necessary to protect precious groundwater resources, to balance the natural recharging cycle, and to maintain the ecological environment. Unfortunately, the U.S. government and its officials have done little to establish relevant regulations to ensure reasonable water extraction for bottled water enterprises in individual watershed regions.[22]

The widespread of operation of bottled water ventures does not only indicate a method of consumption behavior which appreciates the convenience of purchasing water on the go, it also demonstrates unsustainable industrial systems and designs exacerbating the problems of throwaway culture and causing a negative impact and damages that threaten the survival of the planet and of humanity. The excessive consumption of energy for the production of bottled water directly or indirectly involves the issues of global warming and the global energy crisis. The disposable design of water bottles causes the landfill issue, and the PET bottles buried in landfill sites may leak chemicals and pollute groundwater. The existence of bottling plants built nearby watersheds may deplete valuable groundwater resources and impact regional ecological environments. Although the bottled water business has rapidly expanded capturing market share worldwide, that market is not unbreakable. Other than purchasing bottled water, people can choose to spend some time on preparing their own reusable water bottle to help to decrease the negative influences of bottled water industries globally. Even a small change can possibly lead the world toward a significantly better future.

The Management of Water Resources

The rapid growth of bottled water industries reflects people's doubts and fears with tap water and also indicates that the importance of municipal water systems providing everyone safe and affordable drinking water is gradually being marginalized,

and that valuable water resources are increasingly being monopolized by commercial interests and the wealthy. While people living in richer nations distrust the quality of tap water and spend more money on purchasing bottled water, people living in poor countries are struggling and fighting for their fundamental human rights, one of which is access to a clean water source. In 2012, the report by the WHO/UNICEF Joint Monitoring Programme (JMP) for water supply and sanitation, estimated that, as of 2010, over 780 million people across the globe would still lack access to a proven, safe drinking water source, and that is more than 2.5 times the population of the United States. Every year more than 3.4 million people die from poor water, sanitation, and hygiene-related causes, with nearly 99 percent of all these deaths occuring in the developing world. "Access to safe water is a fundamental human need and, therefore, a basic human right," stated Kofi Annan, the former Secretary General of the United Nations, on 22nd March 2001, on the occasion of World Water Day, "contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity." Lack of access to clean water not only causes illness or disease but also impacts children's right to education and the development of macroeconomics.[23]

In Sub-Saharan Africa, one of the world's poorest regions, approximately 334 million people, a figure that represents 39 percent of the total population, lack access to a source of clean water. The absence of clean water usually involves complex and complicated issues of politics, economics, climate, and social structure. As with most developing countries, women and children become the most vulnerable victims. Data shows that about 2000 children die every day from diarrheal diseases which are spread through contaminated water and poor sanitation. Since plumbing infrastructure is not available in many regions, people have to walk for miles to collect water from distant water sources or buy water sold from trucks by entrepreneurs at an expensive price. Women and young girls usually bear the responsibility to collect and manage water consuming much of their time. On average, women walk six kilometers every day to collect water. Due to spending most of their time collecting water, more than half of girls in Sub-Saharan Africa are unable to attend school. According to the website of Water.org, "In just one day, 200 million work hours are consumed by women collecting water for their families. This lost productivity is greater than the combined number of hours worked in a week by employees at Walmart, United Parcel Service, McDonald's, IBM, Target, and Kroger." If the basic right of access to clean water can be achieved, women in developing countries can save more time and gain the opportunity for productive endeavors, adult education, empowerment activities, and leisure. Both women and girls can also be released from the fear of sexual assault/harassment while gathering water. Only after access to clean and safe water source is accomplished in developing countries, can poverty, hunger or AIDS be addressed.[24]

Compared with people in developing countries who suffer from a lack of access to clean water, many people in developed countries purchase bottled water due to fear of tap water. Anxieties about contamination of public water and the distrust of government officials who regulate and monitor municipal water systems lead people to be convinced by advertising and marketing that bottled water can be a healthier, safer alternative. When more and more people turn to purchasing bottled water instead of drinking tap water, the municipal water system may gradually begin to be ignored by the public, and the poor will bear

the brunt of the impact. Hence, the global issue of bottled water is also the fight against the privatization of water. The more people that rely on bottled water, then the less people that will be concerned with supervision of authorities' maintenance of municipal drinking water systems. As Peter H. Gleick notes in the book Bottled & Sold, "If we let our tap water system decay, however, soon bottled water won't be a choice – it will be a necessity, as it is already is in countries without safe tap water." The precious clean water resources ought to be available and easily obtained anywhere. Only when the basic human right to clean drinking water can be protected and guaranteed can an equal and just society be built, and then civilization can advance on a sustainable path.[9]

Campaigns against Bottled Water

Recognizing the threat behind the rapid growth of the bottled water industry, many people have begun to strive for banning or restricting the sales of bottled water. Bundanoon, which is a country town of approximately 2500 people in Australia, is well-known as the first bottled water free community in the world. In July 2009, a total of 356 residents attended a public meeting in the town hall to vote for pulling all bottled water from the shelves in September. "I have never seen 350 Australians in the same room all agreeing to something," said Jon Dee, the spokesperson of the campaign and the funder of Do Something, "It's time for people to realize they're being conned by the bottled water industry." Only two people voted in support of the sale of bottled water. One said that he was worried banning bottled water would encourage people to drink sugary beverages. The other was Geoff Parker, the director of Australasian Bottled Water Institute and represented the bottled water industry in the meeting. Parker argued that the ban is unfair, misguided, and ineffective. "To take away someone's right to choose possibly the healthiest option in a shop fridge or a vending machine we think doesn't embrace common sense," said Parker.[25]

The anger of Bundanoon residents against the bottled water industry was sparked when Norlex Holdings, a Sydney-based beverage company, announced a plan to build a water extraction plant in Bundanoon and sought permission to extract millions of liters of water from the local aquifer. To protect their groundwater and local watersheds from being exhausted by outsiders, the residents of Bundanoon decided to stand up for their benefits and ban the end products of this bottled water industry. Started in May 2009, a campaign named "Bundy on Tap" has been publicly launched and officially declared as a battle against bottled water companies. "We became aware, as a community, of what the bottled water industry was all about," said Huw Kingston, a leader of the "Bundy on Tap" campaign, "So the idea was floated that if we don't want an extraction plant in our town, maybe we shouldn't be selling the end products at all." Preventing lost profits of selling bottled water, businesses in town instead sell reusable "Bundy on Tap" bottles for about the same price. Residents can refill the bottles with chilled, filtered water for a small fee in shops, or alternatively, they can refill bottles with filtered water for free from public water fountains in the main street. No penalty will be imposed if anyone does not comply with the boycott, but all the business owners still voluntarily and willingly agreed to follow it.

"We are very much hoping that this move will get Australians to rethink the half billion dollars a year that they spend on bottled water…we believe that Bundanoon will lead the way on bottled water," Dee said. The act of Bundy on Tap in Bundanoon indicates that the consumption behaviors and habits of consumers can be adjusted and altered in favor of a more sustainable and environmentally-friendly way while having adequate complementary measures. Thus, if the government can effectively promote greater awareness of water related issues by educating consumers about the negative effects of bottled water and establish a well-developed public drinking water system, the demand for bottled water may decrease.[25]

Some groups of faith have also stepped up to call upon a ban on bottled water. They proclaim that the behavior of drinking bottled water is unethical because clean drinking water, like air, is a sacred gift given by God and should not be sold for profit and be privatized by certain groups or individuals. In 2006, The United Church of Canada (UCC), the largest Protestant denomination in Canada, has added "drinking bottled water" to a list of immoral acts. The list also includes participation in the Iraq war and gambling. The church urged its 3 million members across the country to avoid bottled water and drink tap water instead to prevent the monopolization of precious water resources. "Water is a human right, and no one should profit from it," said Richard Chambers, an executive minister in the church. "We are against the commodification, and the privatization is another way to say it, of water in any way, anywhere." This resolution passed by the church's general council in August was prompted by Jordan Newell, who was a high-school student in Springfield, Ontario. "They're taking this clean water, and they're selling it back to us," said Newell, "They're making us scared of tap water, something that is perfectly fine. It's pretty much immoral." And then, in October 2006, the National Coalition of American Nuns passed a resolution asking members to avoid purchasing bottled water as well. Moreover, the United Church of Christ, which partnered with the National Council of Churches, produced a 60-minute documentary "Troubled Waters" which was filmed at locations around the world to capture the stories of evaporating water resources consumed by the world's burgeoning population and privatized by the wealthy and powerful. "The moral call for us is not to privatize water. Water should be free for all," said Cassandra Carmichael, who is director of eco-justice programs for the National Council of Churches. She also noted that an increasing number of religious groups have begun to consider that bottling and selling water to specific people who can afford it is a wrongful – perhaps immoral – act. Rather than calling a formal boycott against the bottled water industry, the purpose of these faith groups is to raise the public's awareness of the issues and promote avoidance of drinking bottled water and to educate the public to the dangers of water privatization.[26]

Having some of the safest tap water in the world, drinking bottled water for people in the United States is more like a fashion trend and a portable beverage option. Although bottled water sales in the United States had experienced serious declines in 2008 and 2009, it soon bounced back and hit a record high in 2010. According to the Beverage Marketing Corporation report, bottled water sales grew by 4.1% in 2011, versus just a 0.9% increase in the U.S. market in general. The statistics shows that although the debates over bottled water have been discussed via the media for years, bottled water is still popular in the country. Thus, if the consumption behavior of purchasing disposable products is difficult to change, some people tend to suggest seeking

other alternatives with more sustainable features.[27]

Polyactic Acid Plastics

In order to face the pressure from the public and hit back at criticisms from environmentalists and anti-bottled water activists, bottled water companies have begun to make great efforts to improve their environmental performance by reducing the use of plastic for packaging. Many scientists and experts have contributed to innovate and develop biodegradable materials instead of petroleum-based plastics, and thus a green trend called "bioplastics" has emerged. Bioplastics are introduced as one solution to consumers concerns with sustainability and negative environmental impact when selecting plastic products. Polyactic acid (PLA) plastic is the most common type of bioplastic which has been widely utilized in people's everyday life. In 1932, the first low molecular weight polymer of lactic acid was made at DuPont Laboratories, and then further research and development was conducted in the 1980s. The discovery of polylactic acid opens a new era in packing technology and industry.[28]

Many people believe that using PLA instead of petroleum-based plastic can be helpful to decrease the impact of plastics on the environment. The concept is that since bioplastics are made of plant material, the excessive use of oil consumed through the manufacture of conventional plastic polymer resins will no longer be a problem, and all plastics sent to landfills will eventually break down and return to the earth. It sounds like a win-win situation. However, the question is whether PLA is really "environmentally friendly," or is it just another trendy marketing strategy to attract consumers to spend more money.

PLA is a thermoplastic aliphatic polyester derived from fermented plant starches, such as corn starch, tapioca roots, or sugarcane. It can be biodegraded under specific conditions because it is derived from 100% renewable resources. Besides rigid containers, PLA can also be manufactured into labels, electronics casings, wrapping for flowers, gift cards, clothing fiber, and pillow stuffing. Due to its variability, it was soon chosen and widely used by industrial designers and industries as a sustainable substitute for traditional petroleum-based plastics. For instance, with the purpose of furthering the philosophy of responsible design, Jim Warner, who is a designer and managing director of design consultancy Brandimage, used PLA plastic as the main material when creating a 360 Paper Bottle in 2008. "Here is the U.S. 60 million plastic bottles are thrown out each year. Only 14% are recycled," said Warner, "I wanted to create something that challenged the norms and was sustainable, elegant, and practical." This innovative, single-serve water bottle is made from 100% renewable materials such as paper, bamboo, or palm leaves etc. Made with a 90-95% reduction in polymers, an internal micro-thin PLA film provides the liquid and air barrier and fuses material to join the two pressed halves together. The top can be peeled off and separated to become a re-sealable lid. This design has won INNOVIC's International Next Big Thing Award for 2009.[29]

The bottled water industry has recognized the potential development and utilization of PLA plastics as well. In June 2002, David Zulter, founder of BIOTA Spring Water, decided to cooperate with NatureWork, LLC (formerly Cargill Dow, LLC), which is a

company developing a bio-based plastic made from corn called NatureWorksTM PLA, to mass produce biodegradable plastic water bottles. Compared with petroleum-based plastic bottles, BIOTA's NatureWorkTM PLA bottles require about 30% to 50% less fossil fuel to produce. Since they are derived from corn, PLA bottles burn clean with zero carbon emissions and do not release harmful chemicals into the atmosphere if sent to an incineration plant. When these bottles are placed under the right composting conditions including high heat, humidity, and micro-organisms, they can biodegrade into water, carbon dioxide, and organic materials within 75 to 80 days. Although BIOTA Spring Water already declared bankruptcy and closed its operation in 2007, it demonstrated the first commercially available compostable bottled water certified by Biodegradable Products Institute (BPI) in the world.[30]

PLA was not widely promoted in the beginning because the cost of corn plastic was too expensive to be applied to mass production until 1989 when Patrick Gruber, a Cargill chemist, invented a new way to produce the polymer more efficiently. Today, as the price for crude oil continues to rise over the long-term, corn-based plastics are starting to become relatively cheap, and thus PLA has begun to become sought after. PLA products are usually labeled "biodegradable" and "planet friendly." 65% less energy is used to produce PLA products when compared to conventional petroleum-based plastics and PLA emits 68% less greenhouse gases. PLA also contains no toxins. Hence, to follow the path of sustainability, some natural food chain stores such as Newman's Own Organics and Wild Oats have quietly begun using PLA plastics for some of their products. In 2005, Walmart, the world's largest retailer, announced its switch from petroleum-based to corn-based plastic packaging that involves 114 million clear-plastic clamshell containers used annually by the retailer for cut fruit, herbs, strawberries, and Brussels sprouts. "With this change to packaging made from corn, we will save the equivalent of 800,000 gallons of gasoline and reduce more than 11 million pounds of greenhouse gas emissions," said Matt Kistler, vice president for product development and private brands for the company's Sam's Club division. This decision indicates the company's effort to transform its corporate image into an environmentally responsible one. "This is a way to make a change positive for the environment and for business," Matt Kisler said at the Sustainable Packaging Forum at the Sheraton Society Hill Hotel.[31]

If the trend of using corn-based plastics can help to effectively reduce the amount of plastic wastes in landfills and sustainably improve the quality of people's living environment, it might be an ideal solution to contemporary throwaway culture, but the invention of bioplastics, in fact, may cause more burden to the environment. Currently PLA still has certain drawbacks that need to be overcome and features that need to be improved.

NatureWorks is the owner of the largest lactic-acid plant in the world which is located in Nebraska. Since NatureWorks is in turn owned by Cargill, the world's largest corn merchant, its lactic acid is all derived from corn. In order to resist pests, most of the corn that NatureWorks uses to produce PLA resin is made from genetically modified (GMO) corn. Environmentalists oppose the cultivation of genetically modified corn and worry that it may contaminate conventional crops and will eventually harm the ecosystem and public health. Furthermore, the growth of corn requires more nitrogen fertilizers, more herbicides, and more

insecticides than any other U.S. crop. The more croplands that are converted to corn fields; the heavier pollutants will be released into the environment. Those chemical and poisonous substances will continuously accumulate in streams and rivers and then cause water pollution and soil erosion. Food security is another concern. Lester R. Brown, the founder and president of the Earth Policy Institute, questions the morality of turning grain for food into packaging when so many people are suffering from hunger in developing countries: "How much corn do we want to convert to nonfood products?" The world's food security depends mainly on the production of the "big three" grains – wheat, rice, and corn. Corn production in the U.S. comprises 40% of the global harvest and two thirds of the world's corn exports, but 40% of the U.S. corn crop is now being consumed for ethanol production. The huge amount of corn being converted to ethanol has already pushed up food prices and impacted poor countries severely. Now the expansion of PLA production may further heighten the demand for corn and encourage more farmers to convert their croplands to corn for its high commodity prices.[32]

In addition, although advocates of PLA claim that PLA is biodegradable and can decompose into carbon dioxide and water within 90-180 days, it will not biodegrade in any natural environment, nor in landfills. The whole composting process can only happen in a "controlled composting environment." That is an industrial composting facility where can reach 140 degree temperatures, contains micro-organisms, and maintains high moisture levels. Currently, there are only 113 industrial-grade composting facilities in the United States, and only about a quarter of them accept PLA plastics from the general public. Very few people can access the sort of composting facilities needed to deal with their PLA plastic products. Since there is a lack of availability of such certified composting facilities, most corn plastics products have the same destiny as PET plastic products that are thrown away by people and eventually buried in landfills in the end.[33]

Some PLA plastics will be delivered to recycling centers, but those are usually considered as troublesome and pose significant logistical challenges for recyclers. Because bioplastics and conventional plastics are derived from different substances which are not compatible with each other, they cannot be mixed together during the recycling process. In the recycling business, all recyclable materials are processed by materials recovery facilities or MRFs (pronounced "murfs"). The materials are then baled and sold to manufacturers as raw materials for new products. The appearance of PLA is identical to some conventional plastics increasing the difficulty for MRFs to distinguish them. There is a new kind of technology which can make it possible to sort bioplastics from conventional plastic recyclables, but the equipment is very expensive, and most recyclers cannot afford the expenditure. Furthermore, the market share for bioplastics is still relatively small compared to the total secondary market for plastics, so it is not worth investing in bioplastic sorting equipment. To prevent PLA from contaminating the recycling stream, especially the PET stream which has high-value end markets, recyclers have to pay for hiring sorters to visually pick out PLA items. Even if recyclers sort out all PLA items, they need to pay again to ship the PLA to an industrial composting site which is usually far away. In most cases, disposing of PLA in landfills, along with the other rejects and residuals, is the more cost-effective option for recyclers. "As a regular resident, you can't compost it. You can't recycle it," says Lauren Norris, coordinator of the Portland area's

master recycler program. "Really, you're giving people something that has to be landfilled."[34]

The initial inspiration for inventing bioplastics is to make petroleum-based plastic items biodegradable, thereby reducing solid waste and saving landfill capacity. However, this idea itself has totally failed too because PLA cannot be broken down in the current landfill system. Typically there are two ways to bury trash in modern society: dump and landfill. A dump is often an open large hole dug in the ground. People come and dump their trash, and various animals such as rats and birds are swarming around. It is most people's idea about a landfill, but dumps are usually illegal because they lack any government regulations regarding the management of waste and the control of groundwater contamination. The sites of landfills in the United States are all licensed and regulated by the Environmental Protection Agency (EPA) and the state's environmental agency. The responsible agencies have to inspect the operation of these sites frequently based on guidelines and legislation to ensure that nearby water is well protected and that odors, vermin, and hazardous materials are all limited as much as possible. In addition, to minimize the potential impact on the environment as much as possible, modern landfills are carefully designed and engineered to be build into or on top of the ground and isolated from the surrounding environment to prevent contamination from entering soil and groundwater. There are many types of landfills. The most common one is the municipal solid waste landfill (MSWLFs) which mainly receive household waste and also receive commercial solid waste, nonhazardous sludge, small quantity generator waste, and industrial solid waste. To protect groundwater and the underlying soil from leachate releases, a minimum of 60 or 40 mil thick (depending on the material used) of flexible membrane (geomenbrane) is constructed by using extremely durable and impermeable synthetic plastic that is applied in MSWLFs as bottom liners. Along the bottom liners, another layer of two feet of compacted clay soil is overlaying and lining the bottom and sides of the landfills. The purpose of the liner system is to separate trash from the land below it and to keep trash dry, so it will not decompose quickly and result in landfill leachate releases which may be dangerously harmful and slowly leak into the nearby environment and contaminate the groundwater system. Under these conditions without contact with air and moisture, not only PLA, but any trash buried in modern sanitary landfill system will not decompose much. After being added to landfills, PLA will never biodegrade or become part of nature again, and thus it will remain intact under the ground for hundreds of years just like conventional plastics.[35]

The problems created by bottled water are not based on the packaging of bottled water and is primarily associated with the attitude of consumers. Rather than seeking a substitute for conventional plastics, a fundamental change in consumer attitudes towards the throwaway culture is the most effective way to make a difference. The bottled water issue can be solved only when consumers can decrease their reliance on bottled water. Nevertheless, the question of why people are so addicted to bottled water is complicated and can be discussed from a variety of different perspectives.

Chapter 2

The Global Obsession with Bottled Water

In the past five years, the sale of bottled water in the United States has unprecedentedly risen and is expected to surpass the sale of carbonated soft drinks by the end of this decade. According to statistics reported by the Beverage Marketing Corporation (BMC), the sales of bottled water rapidly increased from $54 billion in 2002 to $96 billion in 2009. And then, although the growth of bottled water had begun to slow down in 2008 and 2009, attributed in part to the economic recession, the total consumption of bottled water resumed its upward path in 2010 while companies adopted a more aggressive advertising strategy and reduced the price of products. In 2012, the sale of bottled water grew by 6.7 percent, and the total U.S. consumption of bottled water increased to 9.67 billion gallons, up from 9.1 billion gallons in 2011. "I've never seen anything like it," said Michael C. Bellas, who is the chief executive of BMC and who has watched bottled water's rise as an industry since the 1980s. In the meanwhile, the global bottled water industry is one of the fastest expanding industries. The sale of bottled water is expected to overtake that of carbonated soft drinks as the leader in global soft drink category by 2015, according to a forecast reported in April 2013 by the beverage research firm Canadean.[36]

The emergence and growth of global trends in bottled water consumption and demand may be analyzed from the perspectives of wealth, health, lifestyle, marketing, taste, quality, availability, occasion, and habit.[37]

Wealth

Some of the largest growth in bottled water consumption has occurred in developing countries due to improving economic conditions and an increase in prosperity. Although the total in bottled water consumption is not as high as the United States, the growth rate of bottled water consumption rose more than doubling in China and tripling in India in the five-year period from 1999 to 2004. Even while the whole world experienced an economic recession that occurred from December 2007 to July 2009, as was officially determined by the U.S. National Bureau of Economic Research, the bottled water market in China alone still increased 18 percent in 2009. In developed countries such as the United States, the sale of bottled water is also influenced by fluctuations in the economy. U.S. bottled water sales had encountered a serious decline during 2008 and 2009 during the severe economic recession, and then it rebounded and continued to grow again in 2010 because consumers again had more money for spending on consumables, to invest, or to spend on discretionary expenditures with the recovery of economy. "Any household that's truly in the throes of a big budgetary crisis would cut down on bottled water," Jonathan Feeney, a food and beverage analyst at Janney Capital market, noted as an explanation of the connection between the broader economy and bottled water sales. "The fact that people are still buying a 24-pack of bottled water at the local Walmart indicates that perhaps things aren't as bad as you think."[38]

According to mainstream economic theory, throughout history, the consumptive power of society can never be separated from the economic growth rate of a country. Since the Industrial Revolution in the 1800s, the world's population rapidly expanded due to an increased fertility rate and decreased mortality rate. The greater population certainly appeared to have a greater ability

to consume. In the meanwhile, the development of technology, industry, and economic structure dramatically increased consumer goods and promoted the economic growth and prosperity. As a result, a middle class emerged as new consumptive power. With the improvement of economic conditions and living standards, other than the basic need for survival and safety, people's purchasing intentions behind consumptive behaviors have become more complex and complicated. In 1899, a Norwegian-American economist and sociologist Thorstein Veblen introduced the term "conspicuous consumption" in his book The Theory of the Leisure Class. "Conspicuous consumption" refers to extravagant and ostentatious expenditure on acquisition of luxury goods and services that do not satisfy any physical needs, but rather display wealth, power, and status. Veblen used the term to depict the culture of consumption among the wealthy strata of society that formed or existed in the 19th century after the Second Industrial Revolution. Even today, the phenomenon of conspicuous consumption has become more common and can be seen among groups in different levels of society. The thriving bottled water industry has great resonance with the ambiance of consumerism in modern society.[39]

Health

Greater affluence has contributed to more attention being given to "wellness" and healthy living, and bottled water as a product choice which has no calories, additives, or alcohol is advanced as a healthier alternative when compared with sugar-based soft drinks. According to a research study released in 2008 by RNCOS, UK Health Drinks Market, "With increasing emphasis on improving the health conditions in the UK, sales of health and energy drinks, particularly bottled drinking water, have grown considerably in recent years, and bottled water has now become a substitute for tap water in the country." This report indicates that rising health awareness is an important factor accelerating the sale of bottled water. The market is still anticipated to grow further in the future although consumers have started to gain awareness of sustainability issues and doubt the advantages of buying imported bottled water. In fact, many bottled water brands are likely to gain more market share and earn more profits through developing commercial green products.[40]

In the United States, the sharp increase in the occurrence of diabetes among the public has also raised Americans' awareness of sugar intake and significantly affects people's choice of beverage on the market. A statistical report by the American Diabetes Association (ADA) reveals that an estimated 22.3 million people will live with type 1 or type 2 diabetes by 2017, up from 17.5 million in 2007. Over time, diabetes increases the risk of heart disease and stroke and can damage eyes, kidneys, and nerves. The direct and indirect health care costs associated with diabetes had risen from $174 billion in 2007 to $245 billion in 2012. According to another report, approximately 246,000 deaths in 2012 were attributed to diabetes. Diabetes now has become a life-threatening issue for many Americans. While the causes of diabetes are still not perfectly understood, it is believed that obesity is the primary factor causing type 2 diabetes that accounts for 80-85% of the risk of developing type 2 diabetes. Research also

suggests that obese individuals are up to 80 times more likely to develop type 2 diabetes than those with a BMI of less than 22. As a result, Americans have turned to bottled water as a healthy alternative to bottled soft drinks and juices after a fascination with soda pop for more than two decades. Michael C. Bellas, chief executive of the Beverage Marketing Corp., estimates that bottled water sales will surpass sales of carbonated soft drinks and become the number one selling drink in the U.S. by 2020.[41]

Lifestyle

The development of technologies and economies brings civilization to ever higher levels of achievement, but in the meantime, pollutants in the environment and the contamination of food and water have become critical issues threatening people's health. Many people in cities live in a limited space, breathe stale air, and even need to be cautious about the purity of food or water which may contain excess additives and toxic chemicals. The over-industrialized, artificial environment compels people to raise the demand to seek out natural things and to yearn for a better quality of life. Therefore, the market for organic food products has emerged and rapidly expanded. According to a report released by Agricultural Resources and Environment Indicator in 2012, organic food sales in the United States had grown from approximately $11 billion in 2004 to an estimated $27 billion in 2012. This shows that people have started to be aware of the importance of healthy living and become more willing to invest in it. The desire for a more natural and simpler life somehow constructs a type of contemporary lifestyle. Noticing this trend, bottled water companies have developed and enhanced their brand images with associations with nature and purity to meet this trend and attract consumers who are in doubt as to the quality of tap water[42]

The popularity of disposable bottled water also reflects the throwaway culture of contemporary society. Starting from the mid 20th century, the characteristics of the throwaway culture has spread quickly in affluent countries. Even today, the throwaway culture still significantly influences people’s consumption behavior. The words “disposable” or “one-use” can be seen on many products, for instance, plastic sandwich bags, razor blades, cameras, plastic cutlery, paper towels, and ink jet cartridges. Societies, especially in rich countries, consider that pursuing a simple, easy, and convenient way of lifestyle is the best way to demonstrate civilization and advancement. The handy portable packaging of bottled water obviously offers consumers a no-hassle alternative as compared with filtering tap water and carrying a reusable water bottle. Although experts warn that people will eventually pay a high price for treating the world’s resources this casually, the global business of bottled water is expanding to just about every corner of the world. Unless one day the perspective of sustainable thinking and responsible consumption can predominate over disposable consumerism, bottled water will become ever present in people's everyday lives.

Marketing

The strong market schemes of the bottled water industry are a key foundation from which to push the industry towards success. Although it has been proven through much research that bottled water is not any safer or cleaner than EPA-regulated municipal tap water, and that about 25 percent of bottled water is just municipal tap water, people are still willing to pay more than a 4,000 percent markup to buy such a commodity which can be acquired in most households with minimal costs. Richard Wilk, a professor of anthropology at Indiana University, noted that "I think bottled water is the most revealing substance for showing us how the global capitalist market works today...that's the only thing that can explain why you would pay money for a bottle of something that you can otherwise get for free."[43]

To increase the branding value and persuade consumers that it is worth the money, it is essential to promote how the product is different from tap water. Many famous brands like Aquafina and Nestlé usually depict glaciers and mountains on labels to make consumers assume that the water is more pure and directly comes from natural mountain streams. Nevertheless, the real origins of the water may not be as beautiful as the companies describe. In 2003, Nestlé was sued over a claim of false labeling. The Connecticut class action lawsuit took issue that the Poland Spring brand was falsely advertised as originating from springs in Maine when in reality it came from a well surrounded not by nature but by parking lots. In 2012, Nestlé was sued again by a Chicago-based business for falsely advertising its five gallon jugs of Ice Mountain Water as containing natural spring water when in fact they were filled with municipal tap water. It is a common marketing strategy to embellish a product, but when companies cross the line, it will damage consumers' right to know the real content of a product and becomes deception.[44]

In addition to manipulating their product's image by projecting an association with nature, some bottled water companies try to earn support from consumers by enhancing their corporate image by being seen to contribute to charity and environmental protection efforts. Fiji Water is a well-known upmarket brand of bottled water and also the number one imported bottled water in the United States. In 2007, the firm initiated the Fiji Water Foundation that is a charitable trust founded with three priority objectives - to help Fijians to have access to clean water to rural communities, to build educational facilities and infrastructure, and to give access to healthcare services to underprivileged communities. The same year, the company announced an aggressive sustainable growth program -- the "carbon negative campaign" beginning in 2008 and proclaimed itself as the first major beverage brand to give a carbon negative commitment that is to "offset its total carbon footprint by 120%, removing from the earth's atmosphere not only all the emissions involved in the product lifecycle, but also an additional 20%." To achieve this goal, FIJI Water will "account for the carbon footprint throughout the entire lifecycle of its products and then, through a combination of meaningful reductions and carbon-reducing land use and renewable energy projects, the production and sale of each bottle of FIJI Water will actually result in a net reduction of carbon in the atmosphere," according to the press released from Fiji Water. Since then, the slogan "Our Promise, Our Progress" or "Every drop is green" was widely spread and circulated through media channels. Ironically, the dishonesty and hypocrisy behind this seemingly benevolent and public-spirited image created by Fiji Water was soon thereafter revealed.[45]

Fiji Water is now owned by a U.S.-based billionaire couple Lynda and Steward Resnick who bought the company in 2004 from Canadian businessman David Gilmour. It claims that the water is "the earth's finest water" which is directly transferred and bottled from artesian aquifer in the Yagara Vally, a remote part of Fiji's main island, Viti Levu. The company has its own bottling plant in Fiji and extracts more than 3.5 million liters, or about 925,000 gallons, of water every month, and then it bottles the water and ships it thousands of miles to the UK and US. Fiji Water's business is criticized because Fiji, unlike other nations exporting their water, is a poor developing country where 53 percent of its people do not have access to clean, safe drinking water. An article in World Nomads noted that "there are two types of Fiji water: Fiji Water the ubiquitous bottled goodness and Fiji water, the stuff that comes out of the nation's taps, sometimes with shells, frogs and invisible typhoid and gastroenteritis bacteria." The American investigative journalism magazine Mother Jones reported in September 2009 that Fiji Water Company provided drinking water to some villages near the plant and invested in clean water projects across the islands, but half the country had at that time relied on emergency water supplies, with rations as low as four gallons a week per family, and still suffered from water related diseases such as typhoid and diarrhea. Some Fijians had even smashed open fire hydrants to get fresh water. In 2010, the Fijian government announced a raise in taxes on mineral water exports from 0.33 Fijian cents per liter to 15 Fijian cents (about $0.08 USD) per liter, but Fiji Water refused to pay this tax initially and threatened to shut down its factories and place several pending construction contracts on hold. Considering that the retail price of Fiji Water is about USD$1.50 for a 16.9 oz bottle, it was not such an unreasonable request to increase the tax, especially, since this money might be able to be used to improve the local sanitation infrastructure. Although Fiji Water eventually agreed to pay the new water tax, it is morally unacceptable that Fiji Water Company exploits the clean water source, a God-given right, from the poor with minimal tax and then sells it as a fashionable, wealthy icon to the rich at a huge profit.[46]

While some media have praised Fiji Water's carbon negative campaign as an exemplary model of sustainable capitalism, the company has also been under fire for green washing. In 2010, the California-based Newport Trial Group filed a class action lawsuit against the Fiji Water Company in the U.S. District Court in Santa Ana, California on behalf of Southern California resident Desiree Worthington to seek restitution for the false claims from which Fiji Water Company had richly profited. The lawsuit alleged that Fiji Water Company had earned significant profits from its carbon negative claim, but in fact Fiji Water's claims to be carbon negative were misleading and only based on the "concept of being carbon negative." According to the complaint:

"This case is very simple: Defendants convince consumers to buy their "FIJI" brand of bottled water – and to pay more for FIJI than for competing brands –by advertising and labeling FIJI as "The World's Only CARBON NEGATIVE bottled water". In other words, Defendants claim that they remove more carbon pollution from our atmosphere than they release into it. In reality, however, FIJI water is not "Carbon Negative." Instead, Defendants justify this claim by employing a discredited carbon accounting method known as "forward crediting." Thus, Defendants do not remove more carbon pollution than they create; they simply claim credit for carbon removal that may or may

not take place – up to several decades in the future."

Before this lawsuit was filed, Fiji Water's sustainable growth promotion already raised the inevitable ire of environmentalists. No matter how Fiji Water Company reduces its own carbon footprint, it will still have limited control over its suppliers of raw materials, many of whom are located in China. The square signature bottles of Fiji Water are made of high-grade plastic in a diesel-fuel plant in China and then shipped to Fiji first. After bottling, the bottles will be hauled across the oceans to countries around the world. Charles S. Fishman writes in Fast Company magazine that "half the wholesale cost of Fiji Water is transportation–which is to say, it costs as much to ship Fiji Water across the oceans and truck it to warehouses in the United States as it does to extract the water and bottle it." Other than the environmental cost embedded in each bottle of Fiji Water, it also consumes considerable electricity to maintain its business. Since the company requires an uninterrupted supply of electricity that the local utility structure is not capable of supporting, there are three big generators running on diesel fuel in its production facility 24 hours a day. In the words of Fishman, "The water may come from "one of the last pristine ecosystems on earth," as some of the labels say, but out back of the bottling plant is a less pristine ecosystem veiled with a diesel haze." Fiji Water Company has cleverly handled the issue of climate warming and convinced consumers that they can help reducing the carbon footprint if they choose to drink Fiji Water. Behind the striking slogan, the carbon negative campaign is only another promotion demonstrating the wave of "green sheen" advertisements. As a matter of fact, there is no consumption of bottled water which can be manufactured without environmental cost.[47]

The influential marketing of bottled water used to create an impressively powerful image for their products through designing the label and bottle, telling the water's story, and enhancing the corporate image of the company. Besides the quality of water, people buy bottled water for style, fashion, appearance, emotion, or social status. Elizabeth Royte writes in the book Bottlemania that "modern consumers first sipped Perrier, or Evian or Vittel, because it signified. Water, in this case, was a social-not just a physical-resource. Ordering imported water was classy; it improved the tone of a dinner party. Once that idea took hold in America, there was no going back." In the perspective of marketing, bottled water companies are not only selling a bottle of water but also promoting a product to fulfill people's desire for enriching their lives.[48]

Taste

Some people are sensitive to the bad taste of tap water that occurs sometimes due to the treatment process used, the pipes water travels through, or the source of water. Generally, the two common substances which can cause the bad taste of tap water are sulfur and chlorine. Sulfur occurs naturally in many water resources, and it is difficult to eliminate from the water. The chlorine basically comes from chlorination which is universally used in the water purification method. Another source which can affect the

smell and taste of tap water is the metal from the pipe used to deliver tap water, especially when the pipes are too old and need to be replaced. To remove the bad taste of tap water caused by pipe corrosion, it is helpful to run the water for a few seconds or to filter tap water through a tap filtration system before drinking it. People who are concerned about the quality or safety of their tap water can request a water test service from the Department of Public Health. The city water test results is also available for anyone to review.[49]

In the places having good quality tap water, a number of consumers buy bottled water for a different taste or flavor of water. Encouraging this kind of water connoisseurship, like wine connoisseurship, is also a marketing ploy of the bottled water industries. "Fiji has a smooth, silky mouthfeel," said Thomas Mooney, senior vice president for sustainable growth at Fiji. "Most other water from Europe has calcium, which is good for your bones but bad for the palate. Water in Fiji is volcanic, so it has less calcium." The taste or "mouthfeel" of water is an abstract term, a statement with emotional connotation, promoted by bottled water companies to convince consumers that their products are substantially different from the tap water running out from almost everyone's kitchen sink. However, empirical tests have repeatedly proven that they are basically the same. In blind tests, consumers who swear they can distinguish the taste between bottled water and tap water fail to specifically recognize the differences. "Taste for water is as much an effort of imagination as it is an objective fact," said Richard Wilk, a professor at Indiana University who studies bottled water as a cultural phenomenon. "The labels have springs and waterfalls and mountains. The latest waters are from Antarctica and Iceland; there is glacier water and iceberg water and water that is a million years old and water from 3,000 feet down off Hawaii. All of these things promise an untouched nature far from human beings." To say it further, the magical tastes of bottled water are indeed marketing inventions mostly dependent upon consumers' imaginations which are depicted and influenced through advertisements.[50]

Quality

The poor quality of water in some regions might help to boost the sale of bottled water. In China, the quick expansion of industry and agriculture has caused severe pollution in the water supply of many areas. About 70 percent of China's rivers and lakes are contaminated by riverside chemical and power plants, which are strewn with paper, textile, and food production facilities. In Shanghai, the Water Authority of the city indicates that "almost all" surface water has been polluted and does not meet drinking standards. Due to concerns with the contaminants in water, Chinese consumers tend to purchase bottled water as a safer drinking water alternative. In addition, many people in China have moved from rural areas to live in cities for better working opportunities and this demographic trend also contributes to increased sales because drinking bottled water is more common in the cities. Anxieties over water quality has turned into a massive demand for clean water and created an emerging market for bottled water companies. "China is a key priority for us. The market is increasing a lot, and we want to participate in that growth," said Gilles Duc,

the head of Nestlé Waters in China.[51]

Nestlé, which is a Swiss-based multinational company, is the world's No. 3 producer of bottled water and owns more than 60 water brands, including Vittel, Perrier, Aqua Panna, Poland Spring, and Pure Life. While the growth of Nestlé's water business has been slowed in the West because more and more consumers turn to tap water for saving cost or for reducing carbon footprints, it noticed the high growth and profitability of the emerging market in China and recognizes the necessity to increase its presence there. Nestlé's key strategy, allowing the company to successfully seize a market share in China, is to offer middle-of-the-pack pricing. “We want consumers to understand that for the same price they get European technology and Nestlé quality, and if that’s something they value, they go for our brand,” Duc said. In 2012, Nestlé's water business increased by 27 percent and became China's ninth-biggest seller of water. Sales in China is expected to reach $16 billion by 2017, up from $9 billion in 2012, as sales in North America is expected to grow by 18 percent by 2017, to approximately $26 billion. Dermot Doherty, a reporter for Bloomberg News in Geneva, described in Businessweek that "about half of the water Nestlé sells in China is delivered in five-gallon jugs. In Shanghai, Nestlé has opened 12 water stores where customers can phone in orders. Tucked between a pharmacy and a beauty salon, a store in the affluent Lujiazui district sells 400 to 500 containers daily. On the busy street outside, workers stack about two dozen bottles onto electric tricycles for delivery to homes and offices." The problem of water pollution in China creates a strong business opportunity for bottled water industry to promote their products.[52]

Even in developing countries like the United States, it does not mean that people do not worry about the quality of tap water. Many incidents of tap water pollution have been revealed and widely broadcasted via the media. On January 9th, 2014, a chemical spill occurred in Charleston, West Virginia, and up to 7,500 gallons of crude 4-Methylcyclohexane Methanol (MCHM) was leaked into the Elk River, which constitues the major water supply of approximately 300,000 West Virginia residents. The state's governor soon declared a state of emergency in nine counties. Residents in affected areas were urged not to "use tap water for drinking, cooking, cleaning, washing, or bathing." Laura Jordan, an external affairs manager for West Virginia American Water, said that "it could be potentially harmful if swallowed and could potentially cause skin and eye irritation." The drinking water ban was eventually lifted on January 18th, but the water crisis in West Virginia also reflects the potential safety issues of tap water in the United States.[53]

According to a research study by the National Resources Defense Council (NRDC), after evaluating the quality of drinking water supplies in 19 cities around the country, NRDC discovered that overall tap water quality is unexpectedly the same in a number of cities. For instance, Chicago has excellent tap water quality, and most cities have good or average standard quality of tap water. However, in some cities, such as Albuquerque, Fresno, and San Francisco, the water is sufficiently contaminated so as to pose potential health risks to some consumers, particularly to pregnant women, infants, children, the elderly, and people who have compromised immune systems. The NRDC proposes three major recommendations through the report: First, the government of the United States should invest in infrastructure to upgrade deteriorating water systems and modernize treatment

techniques. The water system in many cities, such as Atlanta and Boston, were constructed toward the end of the 19th century. These aging pipes are terrifically fragile and can break and leach contaminants into water and breed bacteria. Second, investment should be earmarked not just for old pipes but also for upgrading drinking water treatment. Most major cities in the United States still utilize the same basic water treatment technologies that have been used since before World War I. These out-of-date techniques cannot effectively remove many human-made chemicals that modern science, industry, mining, and manufacturing have created or released. Third, the EPA should strengthen and enforce existing health standards that are too weak, and draft and enforce new standards for those contaminants that remain unregulated.54 Even though tap water is regulated by the EPA rules, which is stricter in many ways than the FDA's specific bottled water standards, the government should focus more efforts to improve municipal water systems. This is a responsibility that government should undertake to help to reduce the country's reliance on bottled water.

Availability

Water scarcity is becoming a global crisis that exists at all levels and can occur in almost any country. Surging population growth, rapid urbanization, and poor management of water resources all substantially raise the demand for water use worldwide. Climate change also impacts water supplies. Rising temperatures cause the effects of rising evaporation rates, changing rainfall patterns, and the melting of glaciers that feed rivers during the dry season. According to the UN's Water in A Changing World report released in 2009, "While the scarcity of freshwater is felt acutely in Africa and West Asia, water scarcity is already an economic constraint in major growth markets such as China, India, and Indonesia, as well as commercial centers in Australia and the western United States. If current consumption patterns continue, two-thirds of the world's population will live in water-stressed conditions by 2025." The world's water supplies would soon reach a tipping point, but the responses and efforts to hold back this potentially catastrophic dilemma are still negligible. As the water resources in a region are unable to bear ever-increasing demands, importing potable water from other basins may be considered as a quick solution, or the government can only conserve water through agricultural irrigation.[55]

Economic wealth does not guarantee inexhaustible water supplies. Apart from poor developing countries, many wealthy countries such as Australia also cannot escape from the threat of water shortages and have begun to import water from distant rivers and aquifers. The Murray River is Australia's longest river and the main stream of the Murray-Darling Basin. There are 4 major dams, 16 storage weirs, and 15 navigable locks along the river. Furthermore, it is the major domestic water supply for over 1.3 million inhabitants in Adelaide, the capital city of South Australia. Similar with many water-stressed cities in the world, Adelaide is coping with a water crisis which is triggered by consequences of rapid population growth, incessant long-term droughts, and global warming effects. More than 20 years ago, the entire city of Adelaide consumed merely 10% of water produced by the

Murray River. However, nowadays agricultural irrigation alone, especially for cotton and rice, siphons off up to 83% of the basin's water. According to The Guardian newspaper, South Australian MP David Winderlich warned that "another dry year will deplete our reservoirs, and the water in the Murray will become too saline to drink. We are talking about 1.3 million people who are not far off becoming reliant on bottled water. We are talking a national emergency." Importing water is costly and problematic, so the city has begun to conserve water. Effective water conservation requires the efforts of farmers to save water on their end, but farmers in Adelaide have refused to cooperate with a proposal to decrease by 20 percent agricultural irrigation. Therefore, the city has turned to building a desalination plant. Although desalination is expensive and remains an environmental concern that the process of desalination would ruin marine life and the ecosystem, the newly built desalination plant, which has been producing desalinated drinking water since October 2011, allows the city to fulfill the growth in demand until at least 2050.[56]

The world's supply of potable water is running out. Currently, more than half of the world's cities are influenced by recurring water shortages and have difficulties to find additional reliable water resources to support their growth and development. If a region's local groundwater sources are stretched to the limit and beyond, it will be inevitable for people to import water from other basins and to completely depend on bottled water. Although some technologies such as recycling of wastewater and desalination of brackish groundwater can be applied to produce fresh water, the high energy consumption and consequent high greenhouse gas emission problems limit their large scale utilization and could accelerate climate change. Far and away, water conservation is the most sustainable and cost-effective way to secure water availability.[57]

Occasion

Compared to other beverages like coffee, soda, and beer, bottled water is the only all-day beverage. Bottled water companies claim that they are offering a relatively healthier alternative without containing calories, caffeine, alcohol, sugar, color, flavors, or other ingredients. It is also the basis of the argument that bottled water companies use to defend themselves from anti-bottled water activists. In 2010, to respond to a ban against bottled water in Concord, Massachusetts, the IBWA said in a release that "with the current high rates of diabetes, obesity, and heart disease, any actions that discourage or prevent consumers from drinking water – whether tap or bottled – are not in the public interest." Furthermore, in 2013, San Francisco was poised to pass a bill that would ban the sale or distribution of bottled water in plastic bottles of 21 fluid ounces or less on public property, including in parks, at concerts, from mobile food trucks, and at city-permitted events. The IBWA issued a press release seeking to refute the argument that bottled water should be banned: "Efforts to eliminate access to bottled water on San Francisco city or county property will force people to choose less healthy drink options, which have more packaging, more additives (e.g., sugar, caffeine), and greater environmental impacts than bottled water. Moreover, this legislation would mean that there would be no bottled water available on city or county property for immune compromised people or during emergency situations when tap water is

compromised." It is undeniable that the sale of bottled water provides a convenient way for people to satisfy their water intake needs, but it absolutely is not the most indispensable and sustainable option. Especially it offers no more health benefits than tap water. With access to clean and safe water, the obsession of buying bottled water is incredibly wasteful and environmentally harmful. Indeed, in the long run, the prevalence of bottled water will accelerate the inequitable distribution of water resources which should not be privatized by any person or corporation under any circumstances. Often, the longest way to success is a shortcut. Although it might require plenty of time and money to implement a comprehensive system of water refilling stations and water fountains, it is the only and the most efficient way to decrease the influence of bottled water in society.[58]

Habit

Recognizing the unnecessary waste and environmental cost of bottled water consumption, many municipalities have proposed and enacted a ban on bottled water. Residents of a rural Australian town, Bundanoon, voted to replace single-use bottled water with refillable bottles in 2009. They are believed to have become the world's first community to ban the sale of bottled water. As part of the ban, Bundanoon has expanded drinking water facilities and set up a water refilling system that people can have chilled, filtered tap water in shops with a small fee or refill water from public water fountains on the streets for free. In the United States, the town of Concord in Massachusetts is the first municipality to ban the sale of single-serving water bottles smaller than 1 liter after a three-year campaign led by an 84-year-old resident Jean Hill. This bill went into effect on January 1st, 2013 and allows an exemption during emergencies. Under terms of the ban, first offenders who violate the ban and sell bottled water will receive a warning. Second-time offenders can be fined $25, and third-time offenders and beyond can be fined $50.[59]

Not every resident in Concord agrees with the bill. The IBWA lashed out against the bill with a statement: "This ban deprives residents of the option to choose their choice of beverage and visitors, who come to this birthplace of American independence, a basic freedom gifted to them by the actions in this town more than 200 years ago. It will also deprive the town of needed tax revenue and harm local businesses that rely on bottled water sales." Many store owners worry that this ban will have a negative impact on local business. Some people question that this ban will definitely cause inconvenience to residents in Concord, but the benefits and effects of the ban to the environment would be minimal. Consumers can still purchase large bottles in stores or simply drive to neighboring towns to purchase bottled water. “Towns are close enough that people can walk two minutes and go get it from Acton or Bedford. It doesn't really help I don't think," said Jenny Fioretti, a local resident who opposes the bill. [60]

To make lives easier, consumers used to pay more for convenience to eliminate undesirable hassles and trifles of life. Sometimes, convenience can largely refer to a form of service. It is not a necessity but a choice aimed to provide an aspect of a pleasant, effortless, and comfortable way of life. For instance, people do not cook at home and choose to go to restaurants for meals, so they can save time on shopping in markets, preparing food, and cleaning dishes. In the meanwhile, people pay to enjoy

sophisticated cuisine, warm greetings from waiters/waitresses, and a lovely dining environment. Everyone knows that it is healthier and cheaper to cook at home, but dining out in restaurants has already accounted for a large proportion of household expenditure for many families. The popularity of bottled water can be explained from the same basis. When consumers walk into a store, grab a bottle of water from a refrigerator, and pay up to one thousand times the cost of tap water, they assume that they are not just buying a bottle of water. The expensive price of bottled water also includes the cost of "service" that a "professional team" draws water from a "selected natural spring aquifer," purifies the water with advanced technologies, and then cautiously bottles and packages it before the bottles of water are delivered to local stores. Hence, consumers can sit leisurely on a couch and have a glass of water from "a protected artesian aquifer found deep underground in the remote Fiji Islands" or from "a pristine origin in the snow capped peaks of the French Alps." Consumers also pay for the benefits of saving time on filtering tap water and cleaning reusable water bottles. The concept of paying for convenience continues to dominate people's life methods and consumption behaviors and somehow becomes a cultural trait, a norm, and a habit.61

To change the habit of relying on bottled water, three actions can be taken: First, the government should assume responsibility for analyzing the impact of the bottled water industry on the environment and to promote the importance of municipal water to the public. If people are well informed, educated, and recognize the heavy environmental cost behind the sale of bottled water, they may readily change their habits to drink tap water instead of drinking bottled water. Second, the government should maintain the nation's water infrastructure to guarantee the quality of municipal water and reinforce the drinking water refilling system in most public spaces. Thus, as long as people have a water bottle with them, they can get a refill of high-quality drinking water anytime and anywhere. A well-functioning drinking water refilling system can increase people's intention to carry reusable water bottles instead of purchasing bottled water in stores. Third, the government should consider imposing restrictions on bottled water sales to force consumers to modify their habits in favor of sustainability. The expansion of the bottled water industry has caused a considerable negative environmental impact and threatened the basic human right of access to clean water in poor regions worldwide. Although people who support bottled water claim that a restriction on sales of bottled water restricts their right to choose whatever they want to drink, it is obviously unfair and unjust to ignore the best interests of the majority of the world's population and to focus on convenience for a minority whom mostly live in wealthy regions and acquire the world's most resources.

The government has the responsibility to ensure that the development of a country is heading toward a sustainable blueprint. Once the government cannot appropriately and effectively play its role, then it becomes a responsibility of every citizen. This is why Jean Hill stood up to promote the ban on bottled water in Concord and gained the support of the public. "We are not willing to put convenience ahead of our concern for the near and long-term consequences of bottled water," Hill said in an interview with the Concord Conserves. "In order to help people change, you need to put policies in place that steer them away from buying bottled water and toward considering the many other good alternatives." Concord's ban on the sale of bottled water

may not be able to considerably reduce plastic waste and bottled water sales in a short time, but it will be a model, a beginning. The spirit of the ban, which aims to lead people to think more before paying for convenience, will inspire more and more people in the United States to consider the negative consequences arising from the habit of drinking bottled water and, perhaps, to alter their habit of relying on bottled water.[62]

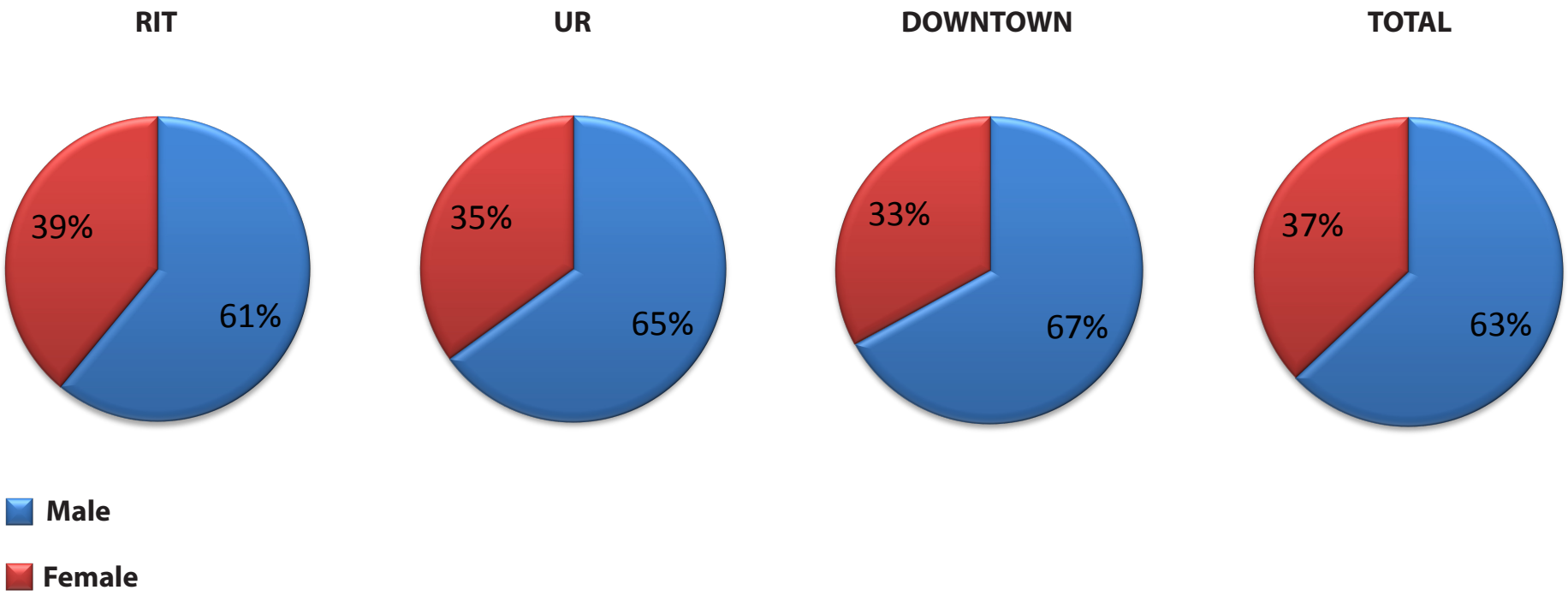
The issues of bottled water are quite complicated and involve factors to consider regarding pollutants, water shortages, cultural values, commercial behaviors, consumption behaviors, a disparity between the rich and the poor and unfair distribution of resources. Any simple solution is unlikely to solve all the issues immediately, but aspects of these issues are possibly alleviated or addressable through educating the public or increasing their awareness, such as promoting the habit of drinking bottled water. The less people drink bottled water, the less bottled water impacts society, the planet, and the public health. Thus, after analyzing these factors accelerating bottled water consumption around the world, I decided that the next step of my thesis will be to focus on how the user experience of carrying a reusable water bottle can be improved in order to encourage more people to willingly carry their own reusable water bottles, and as a result, to help people to decrease their reliance on bottled water and build the habit of drinking tap water.

Chapter 3

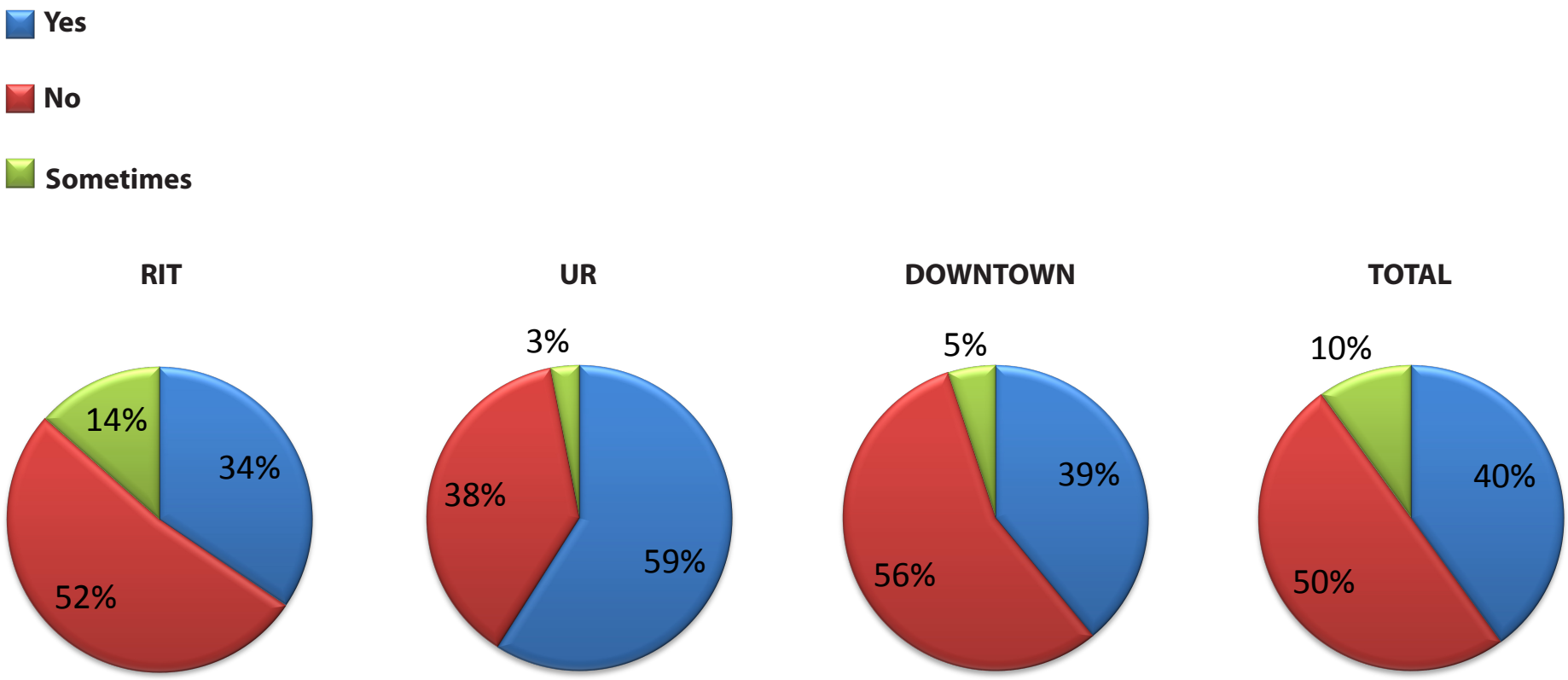
Consumer Behavior Survey

In order to understand further about consumer habits regarding bottled water, I designed a survey to collect information about consumers' habits of carrying a reusable water bottle, the bothersome aspect of carrying a bottle, and consumers' expectation of an ideal water bottle. My target audience is users who spend most of the time outside their homes and have the need to consider the availability of water, for example, students on campus or employees in office space. Therefore, I did the survey with students and faculties at RIT, students of UR, and employees in Rochester Downtown through paper-based questionnaire, online questionnaire, and direct face-to-face interview. In the end, I collected a total of 171 results, and there were 70% from RIT, 20% from UR, and 10% from Rochester Downtown. The survey questions and results are as following:

1. **Gender**:

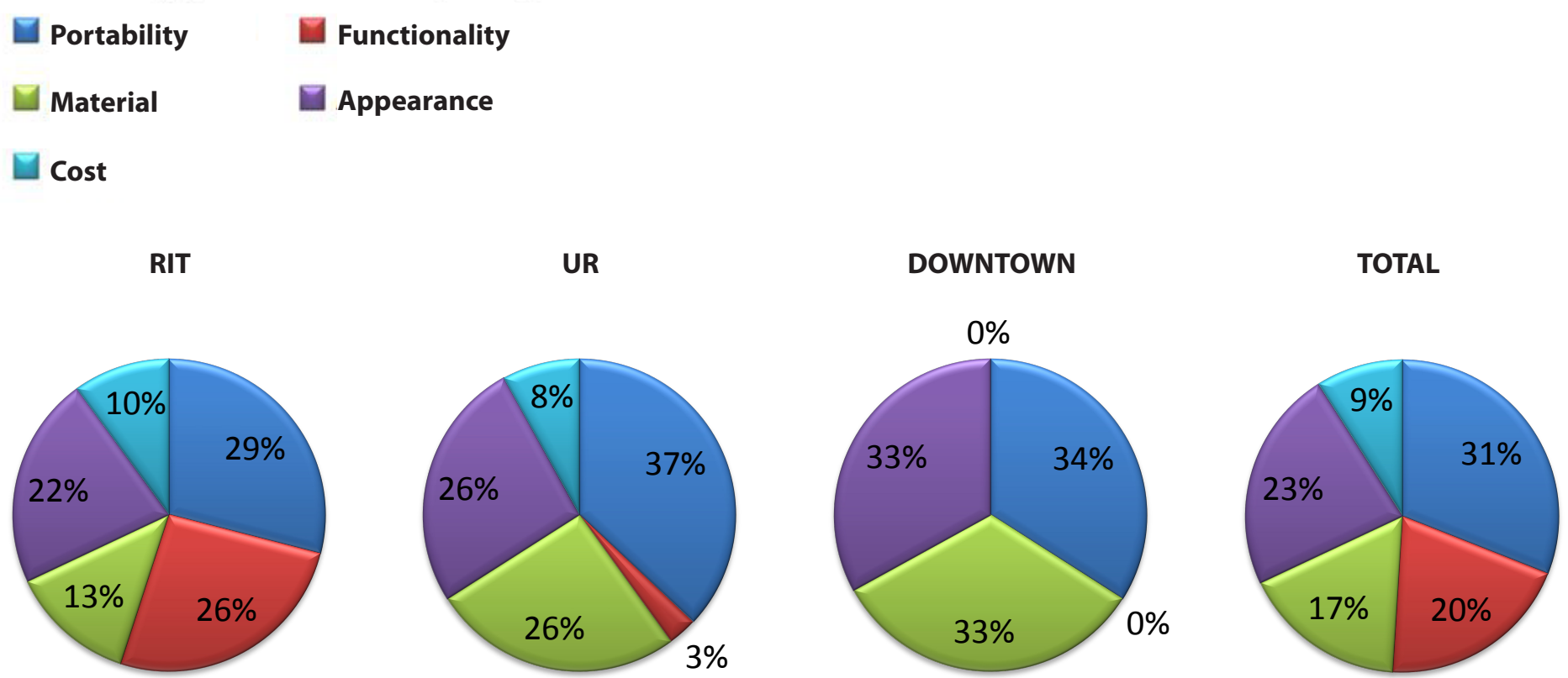


2. Do you used to carry a reusable water bottle with you?



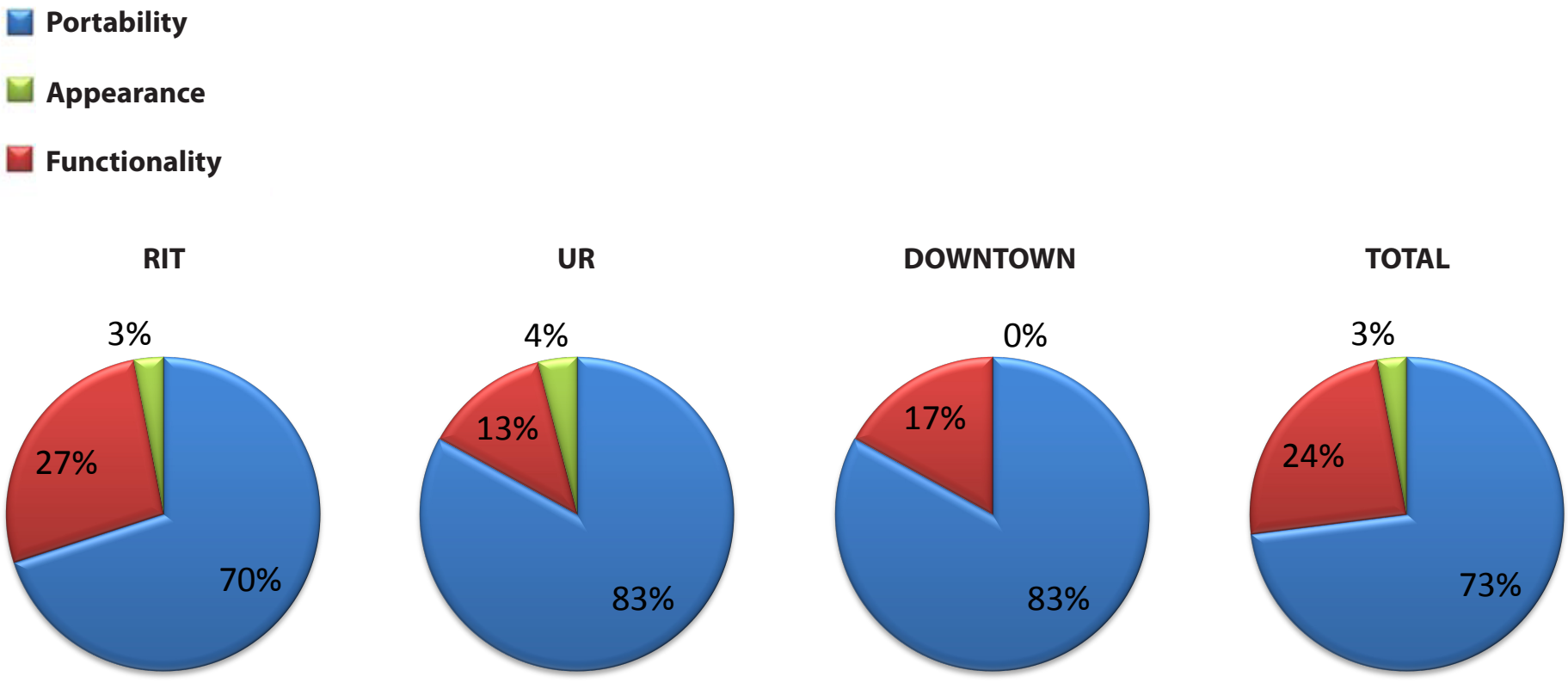
Based on the survey, approximately 50% of the respondents do not have a habit to carry their own reusable water bottles. Some of them mentioned that they had their own reusable cups at schools or workplaces, but they might purchase bottled water for convenience when they were traveling or away from home. About 10% of the respondents said that they would bring reusable water bottles sometimes when they had time to prepare or need to go on a trip. It shows that more than 50% of the respondents who are the consumers or potential consumers of bottled water. Even though they do not drink bottled water everyday or frequently, bottled water is still part of a way of their lives.

3. If you used to carry a resuable water bottle, what factor is the most important to you when selecting and purchasing a reusable water bottle (multiple choice)?



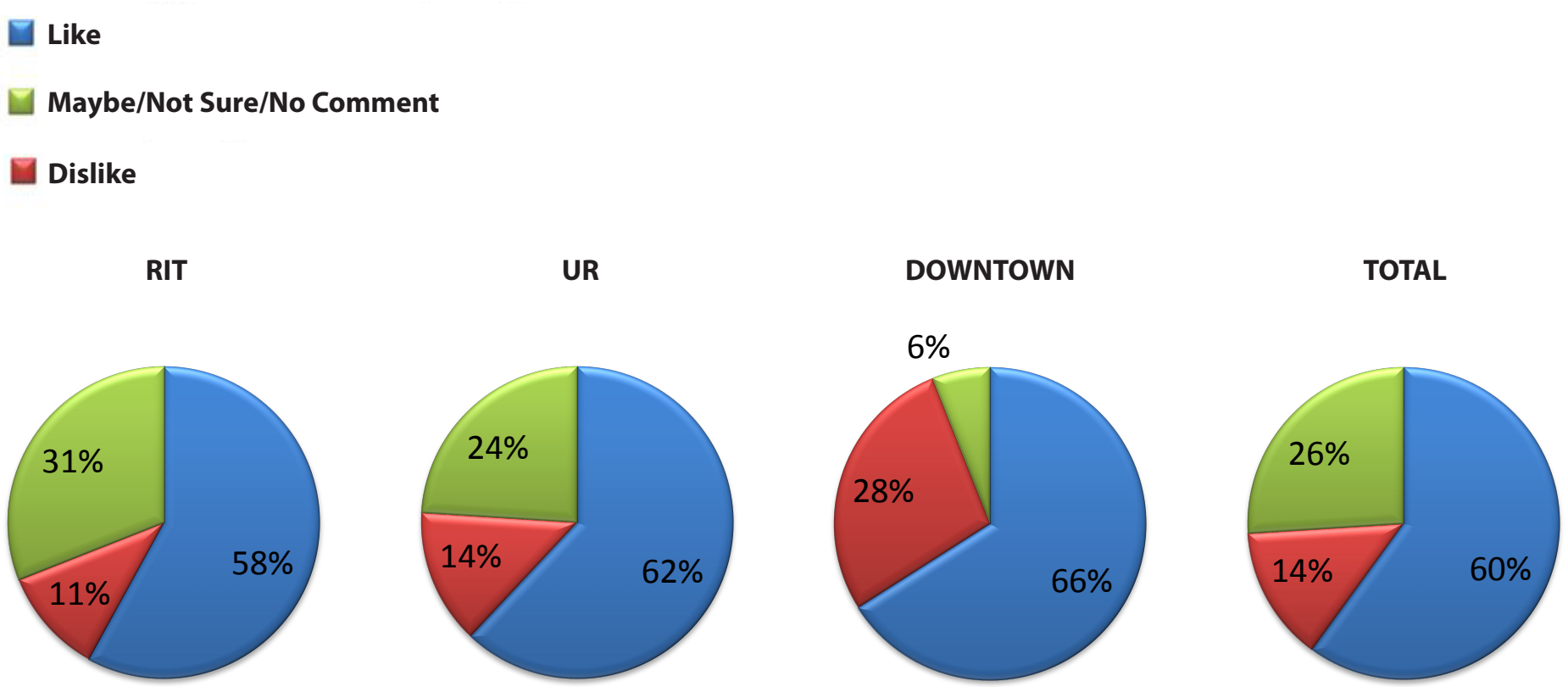
When selecting a reusable water bottle, in general, portability (31%) is the first priority for users to concern about. The second and the third are appearance (23%) and functionallity (20%). Users with different professional backgrounds may have different preferences. For instance, the UR is famous for its Medical School, so consequently many respondents who were from UR emphasized through the survey that the materials of a water bottle had to be nontoxic and BPA free. Similarly, a substantial part of respondents who were from RIT were studying at CIAS, so they focused more on functionality when respondents who were from UR and Rochester Downtown were not concerned about functionality that much.

4. What is, or would be, the most bothersome aspect of carrying a reusable water bottle with you (multiple choice)?



The most bothersome aspect of carrying a reusable water bottle obviously is portability. The weight of water bottles is a hassle for users to carry around, and carrying an empty bulky bottle is even more annoying for users. Some respondent mentioned that it would be ideal if a bottle could be as small as possible or could be folded and inflated. It shows that whether a bottle is handy enough has a significant influence on users' willingness to carry a reusable water bottle. In addtion, several respondents also mentioned that they felt bothered about losing bottle caps, leaking problem, and keeping water chilled when carrying a reusable water bottle.

5. What do you think of the idea of a collapsible or flexible reusable water bottle?



More than half of the respondents (60%) like the idea of a collapsible or flexible reusable water bottle. A number of the respondents who are not sure about this idea (26%) said that they were worried that it might cause leaking problem or increase the difficulty to clean a bottle. The respondents who dislike this idea (14%) said that whether a bottle was collapsible or flexible was not important for them because they did not think that it could affect their decisions to choose a bottle. On the whole, the idea of a collapsible or flexible water bottle is in line with public expectations.

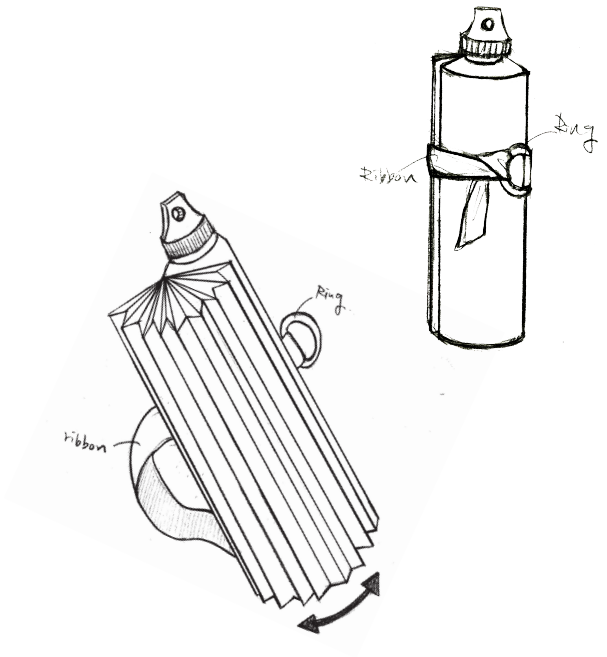
Chapter 4

The Concept Development

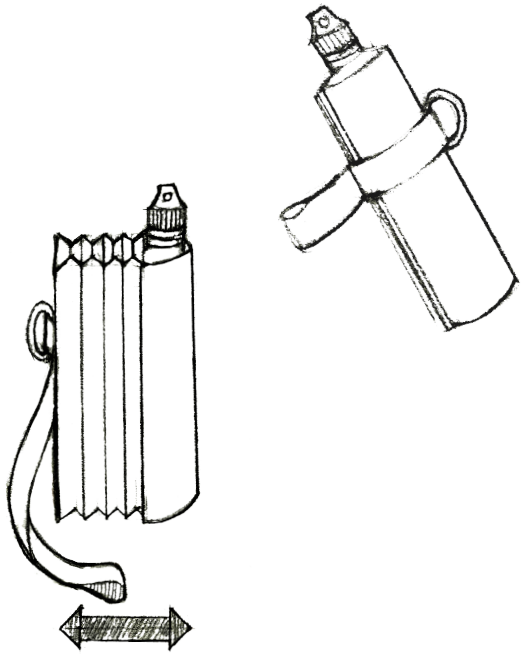
Beginning Concept

Based on the results of survey, a mojority of the respondents expressed that they were most bothered about the portability of reusable water bottles, and more than half of the respondents said that they liked the idea of a collapsible or flexible water bottle. Therefore, I believe that a more compact and portable design of water bottles can better meet users' needs and increase users' willingness to carry a reusable water bottle with them. Hence, I decided to begin with collapsible and foldable ideas.

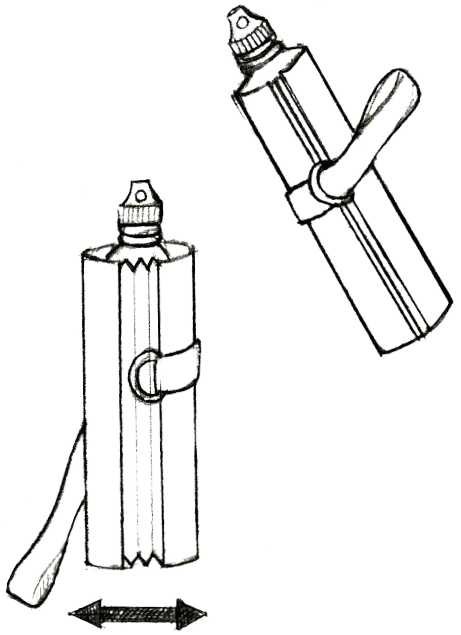
Concept A



Concept B



Concept C

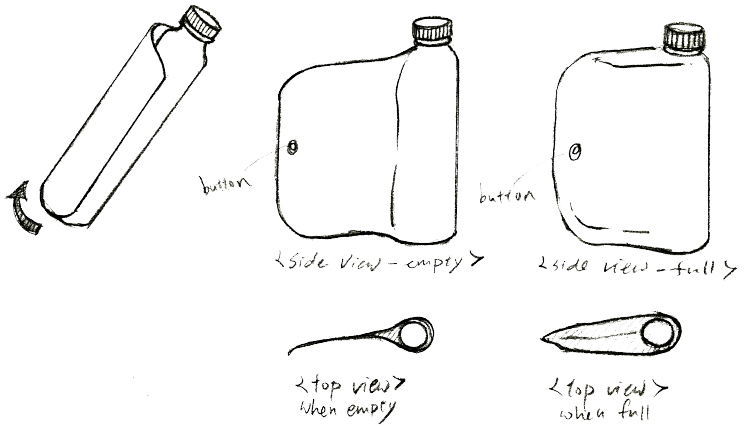


Concept A, B, and C are collapsible bottles. The bodies are expendable, so the size of the body will be changed depend on the volume of water inside. When the bottles are empty, users can tie the ribbon attached on the bottles to compact the size. The ribbon and ring can also help users to carry and tie the bottle.

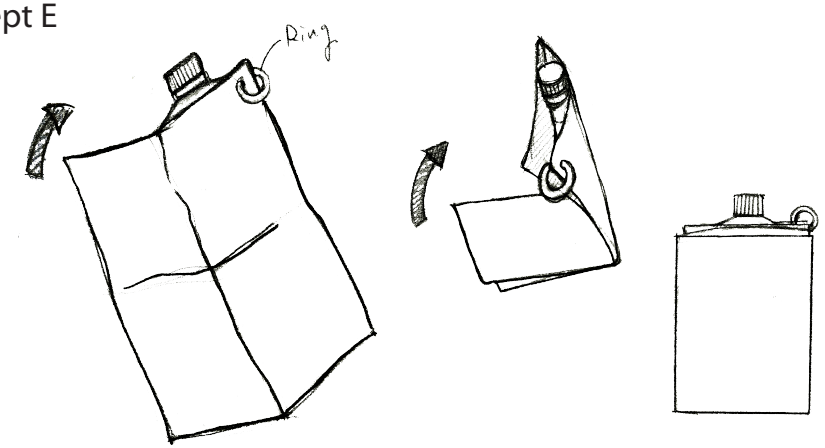
Beginning Concept

Concept D, E, F, and G are foldable bottles. These ideas are inspired by folding papers. The bottle is made by flexible materials, so when it contains water, the size of bottle is equal to the volume of water inside. When the bottle is empty, the body can be rolled or folded, like a piece of paper, and can be placed into a tiny space.

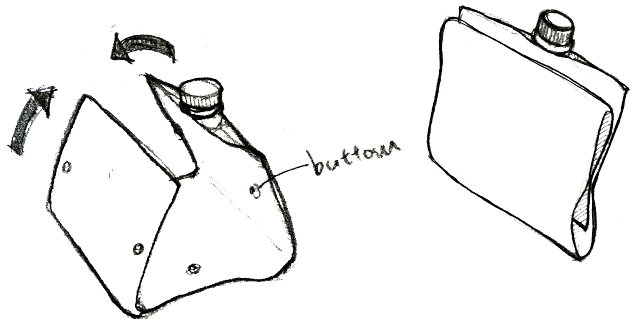
Concept D



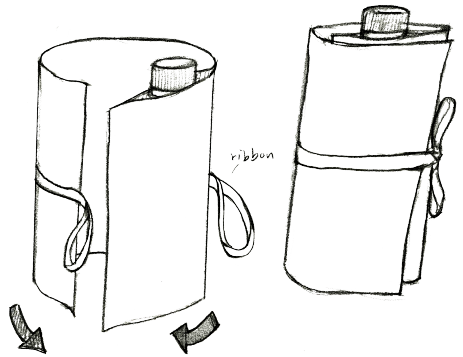
Concept E



Concept F

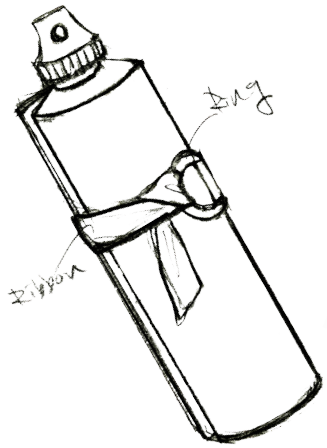


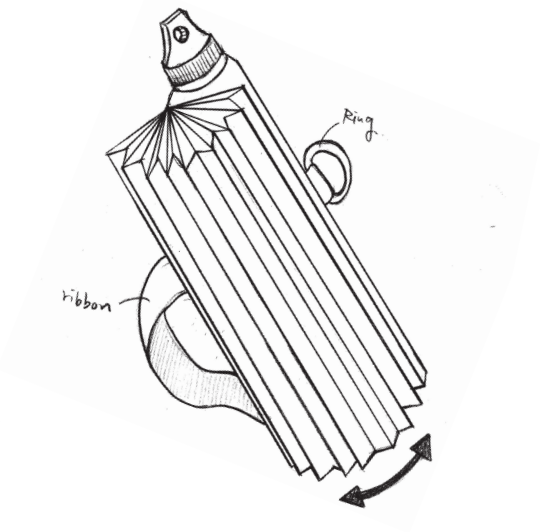
Concept G



Beginning Concept Mock-up

Concept A

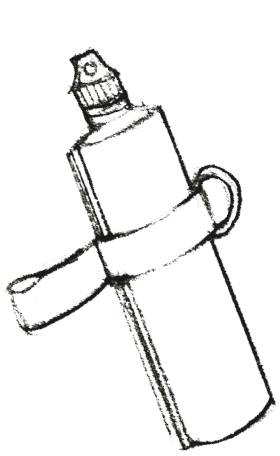


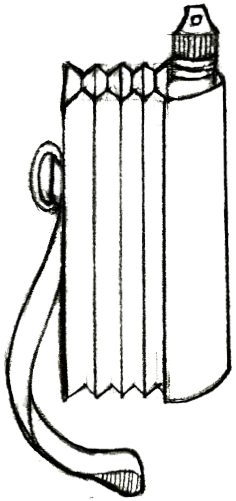


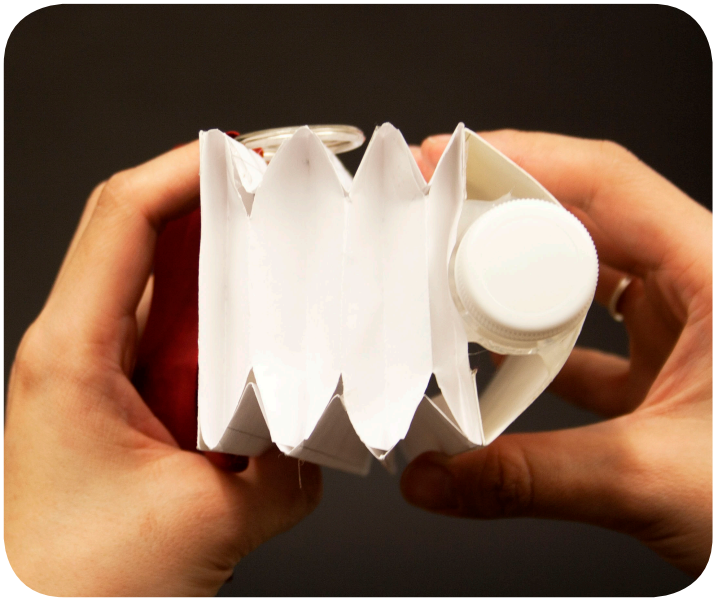
To study the feasibility of the collapsible and flexible concepts, I made several actual paper mock-ups. The collapsible concepts (Concpet A, B, and C) turned out nicer than I expected. The red ribbon and collapsible design make it royal and elegant. However, the flexible ideas (Concept D, E, and F) have better functionality compared to the collapsible ideas. To achieve my original purpose of creating a compact and handy water bottle, I chose the flexible idea to develop.

Beginning Concept Mock-up

Concept B

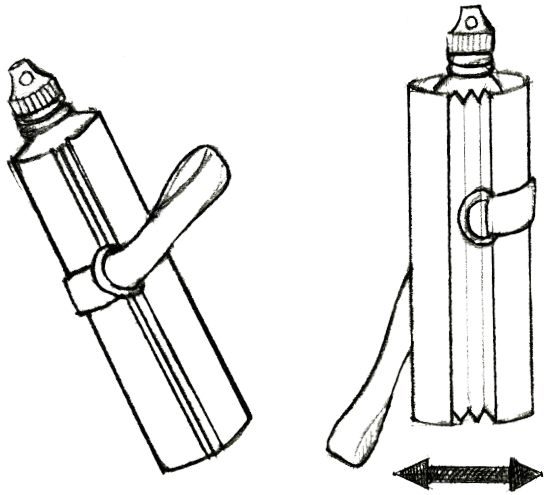


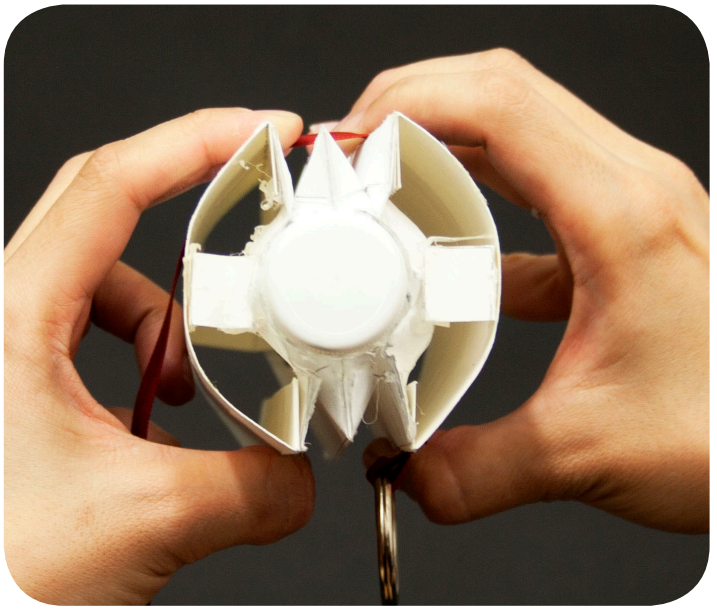


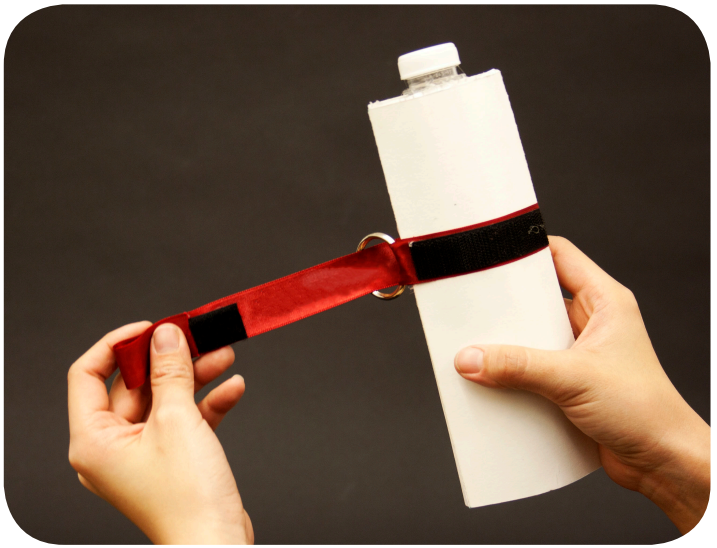


Beginning Concept Mock-up

Concept C

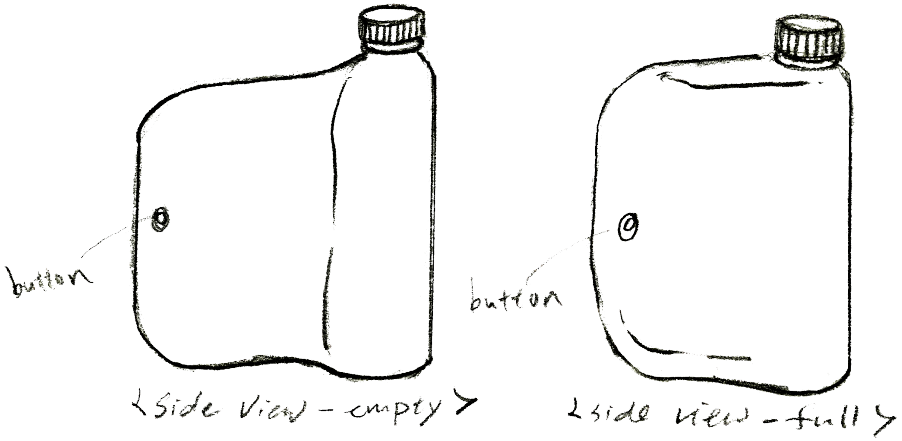


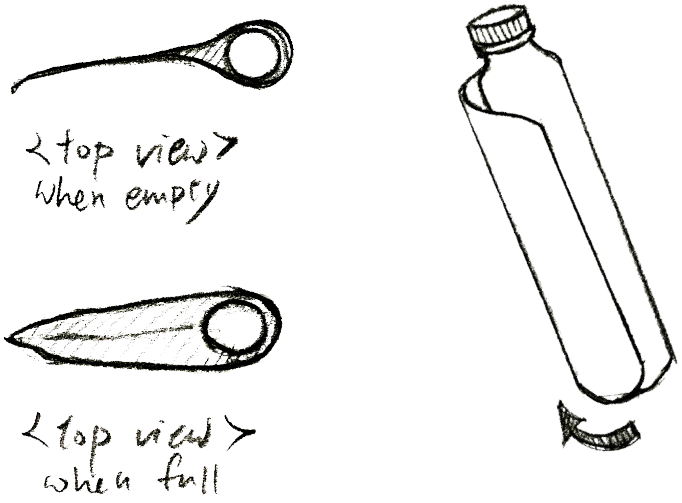




Beginning Concept Mock-up

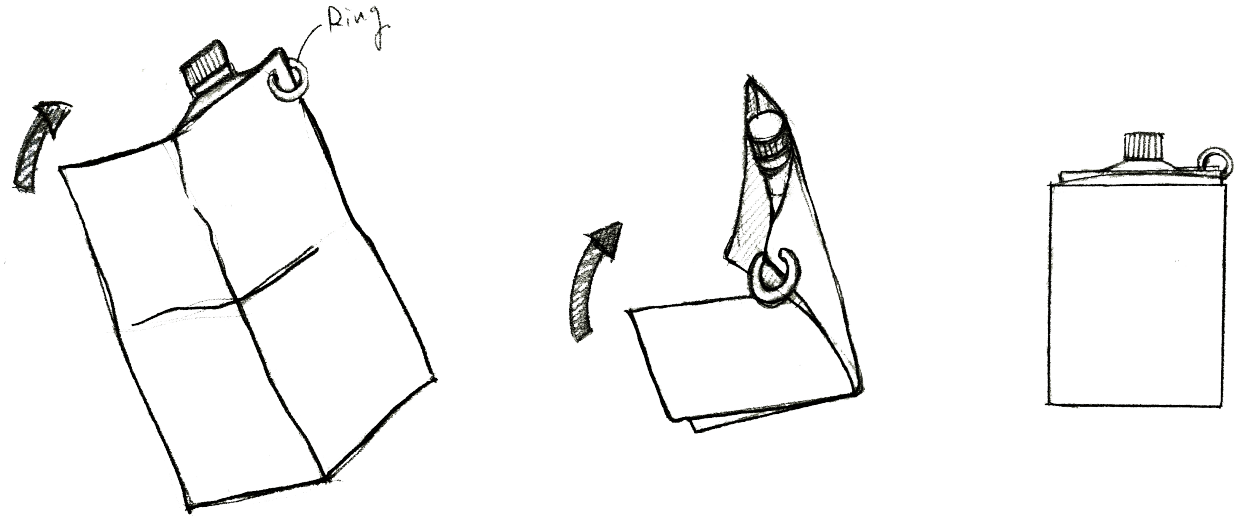
Concept D

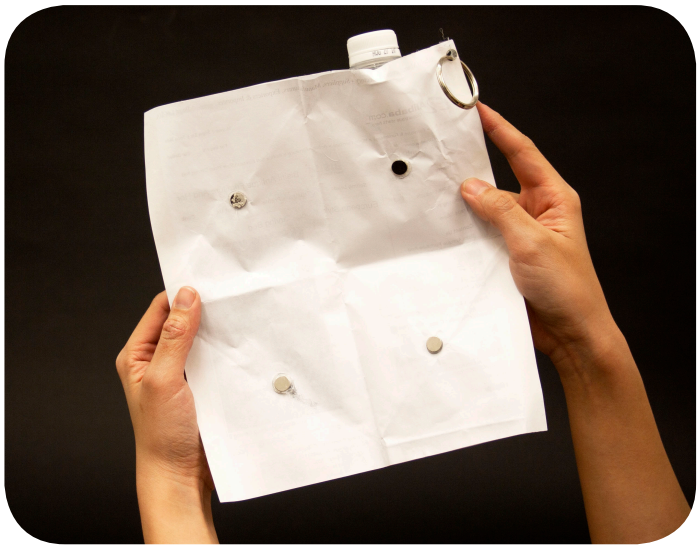




Beginning Concept Mock-up

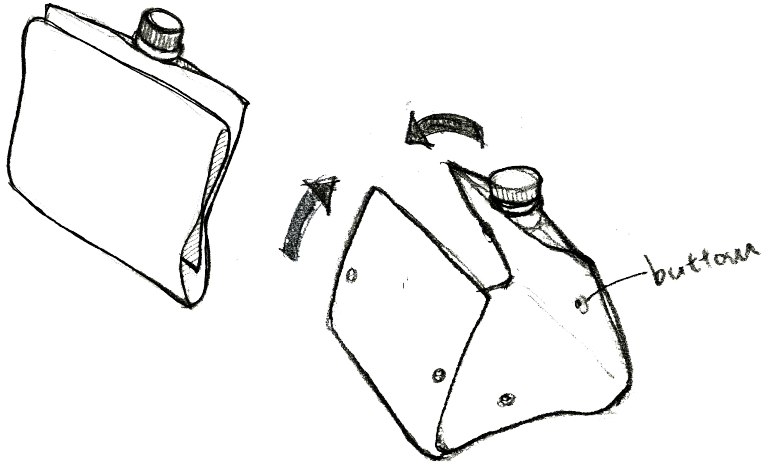
Concept E

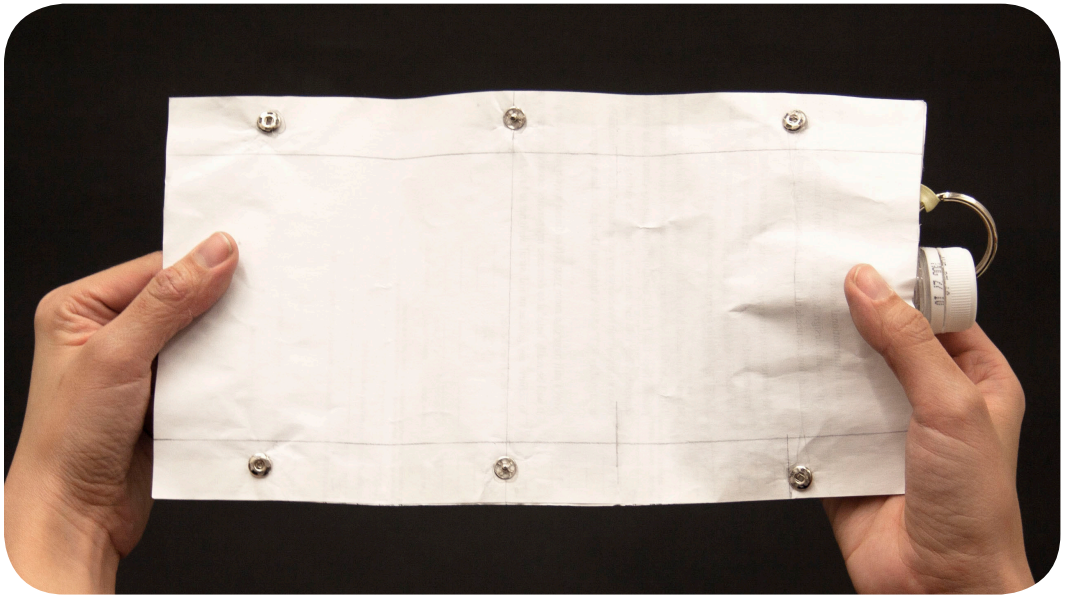


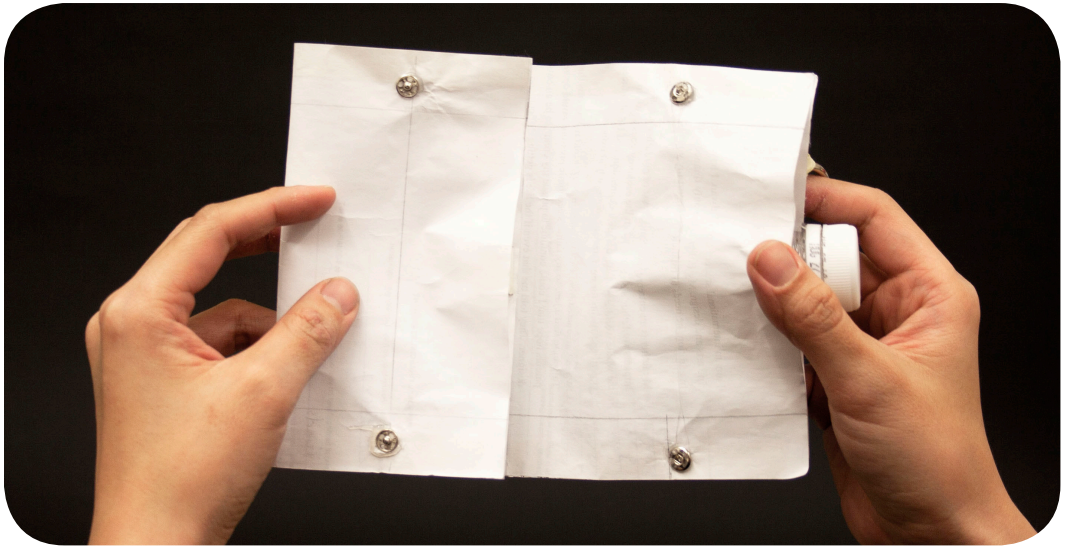


Beginning Concept Mock-up

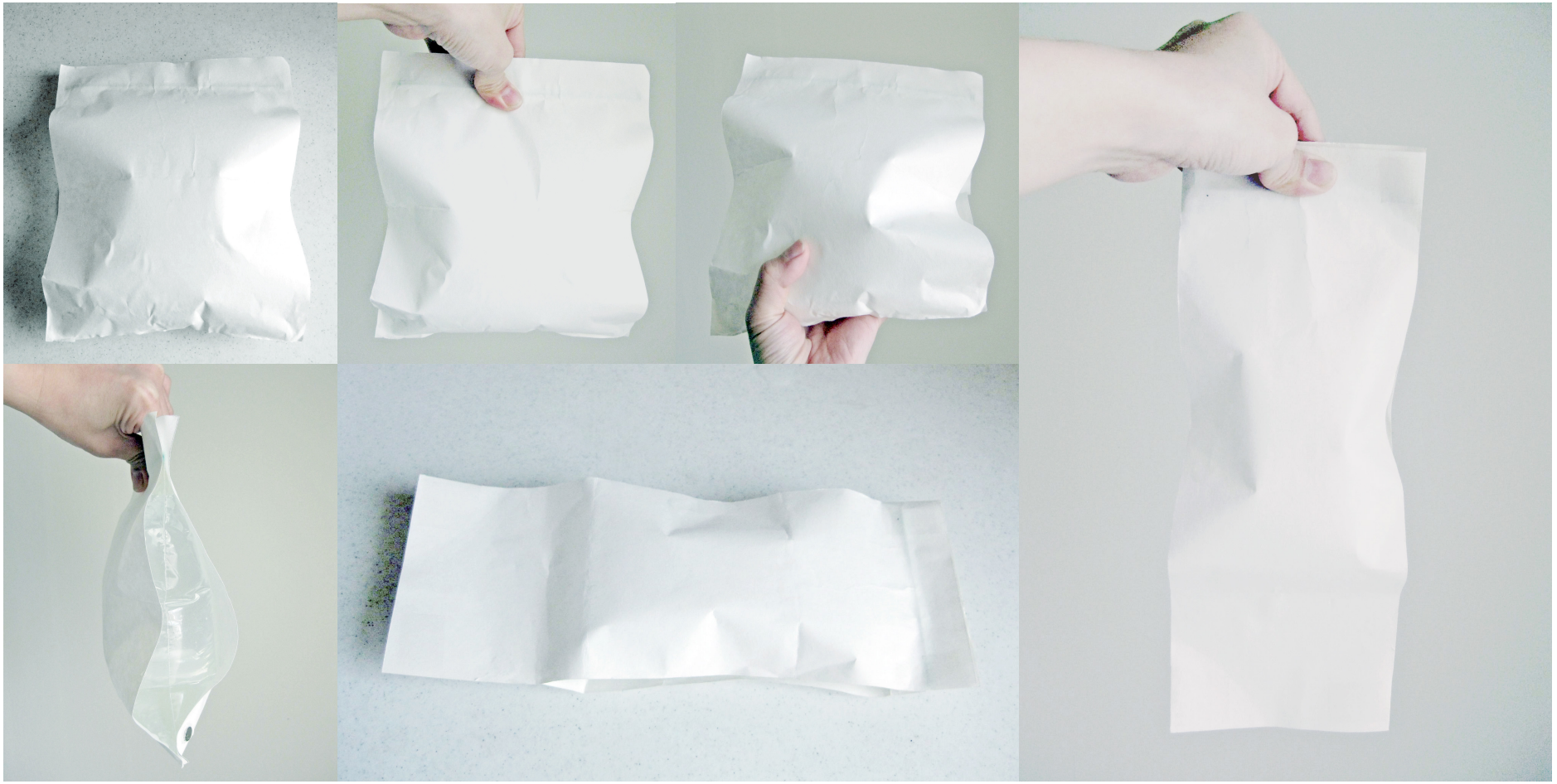
Concept F





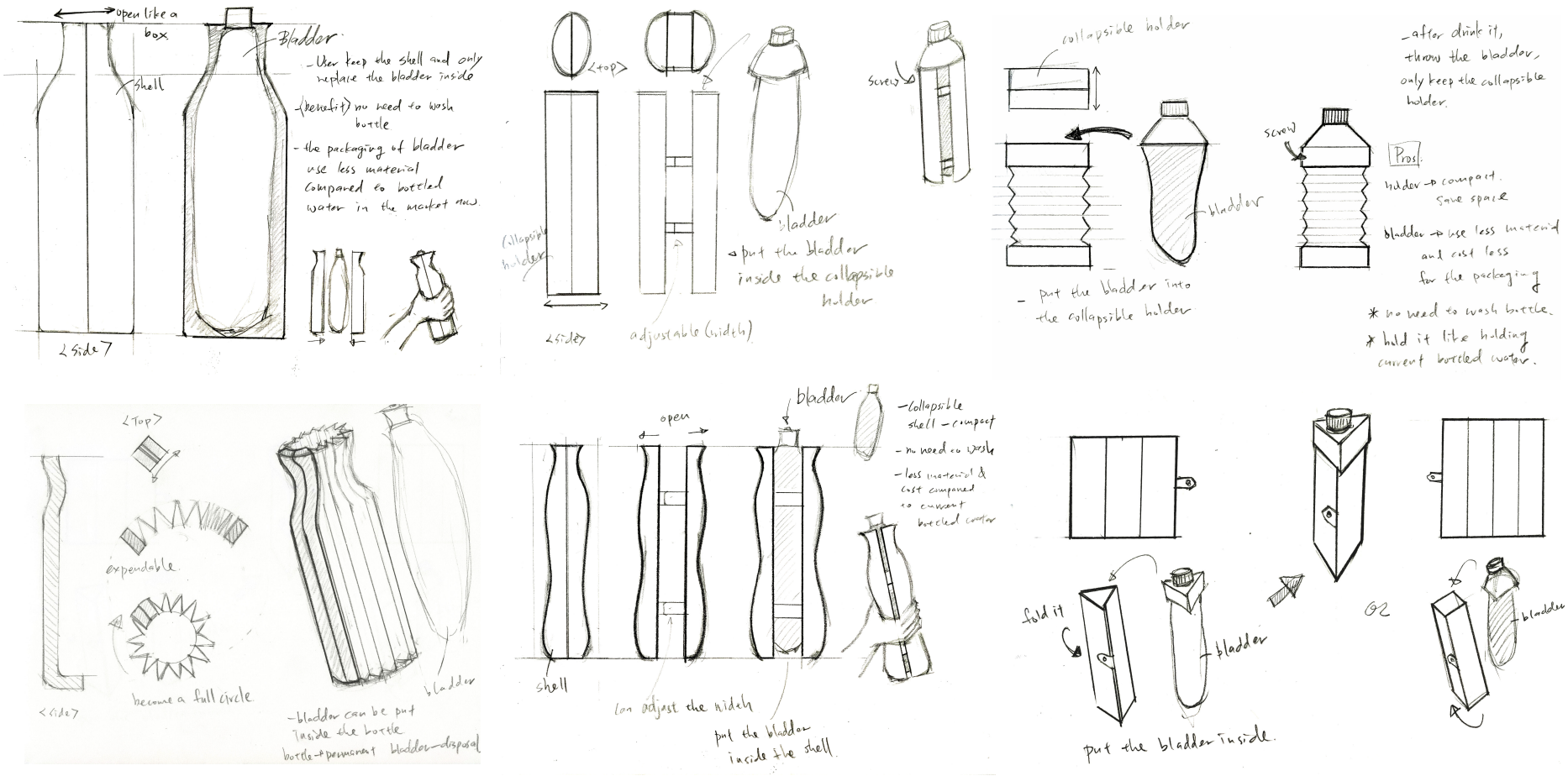


Mock-up with Water



In order to know how it feels like to hold a flexible wate bottle containing full of water, I used papers and plastic bags to make water pouch mock-ups. Through this experiment, I found that holding a soft bottle is really unstable, and users may feel really insecure to hold and drink water from it. Therefore, it is necessary to refine this concept and to make it sufficiently stable to be used by users.

Refined Concept I

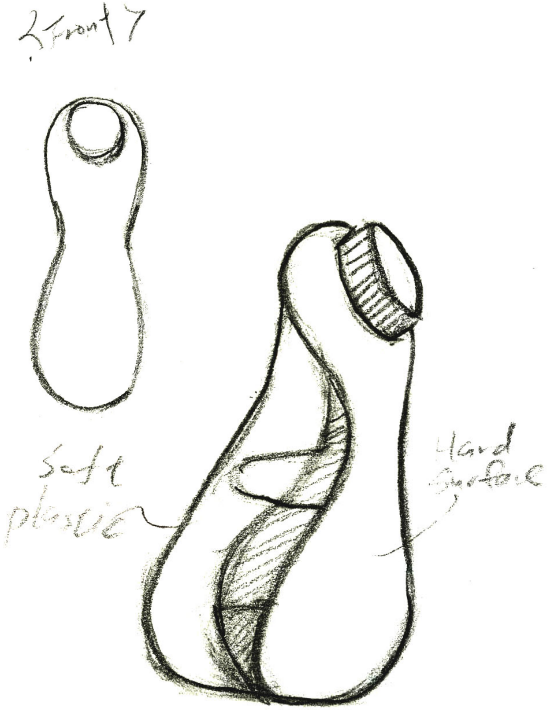


To steady the flexible water pouch, I came up the **semi-disposable idea**. It involves attaching a flexible pouch to a holder. The holder is permanent and reusable, and the flexible pouch is disposable. Users purchase a pouch containing drinking water from stores and then assemble the holder and the pouch together by themselves. These sketches show different structures of holders and water pouches. I gave up this concept quickly because the disposable idea was against my original purpose to create a sustainable product which should be long-lasting and can be used repeatedly.

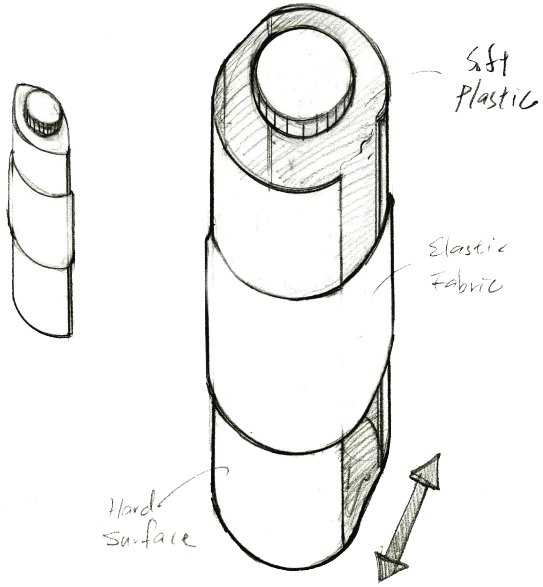
Refined Concept II

I revised the semi-disposable idea and developed another concept **flexible pouch with supporting shell** (Concept H, I, and J). The flexible water pouch is fully attached on one or two pieces of supporting shells. The curves on the bottom of supporting shells allow the soft bottle to stand on it is own. Among these three concepts, I chose Concept H to develop further because the organic shape of supporting shell is more ergonomic for users to hold it.

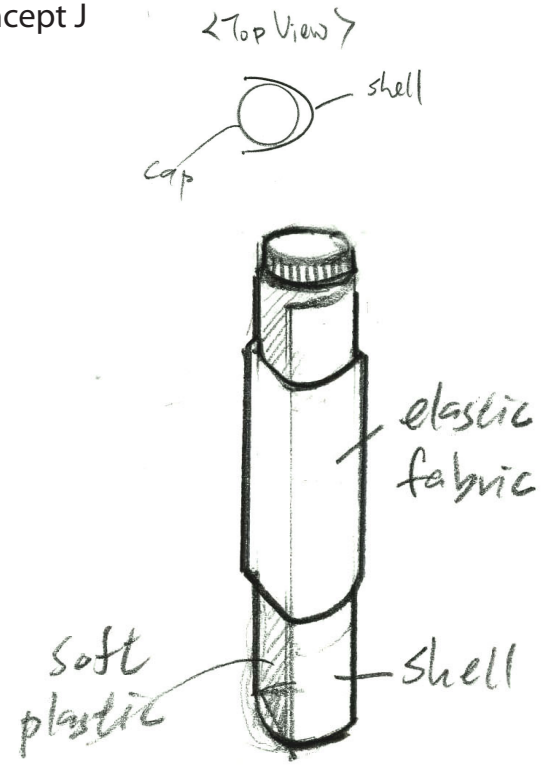
Concept H



Concept I



Concept J

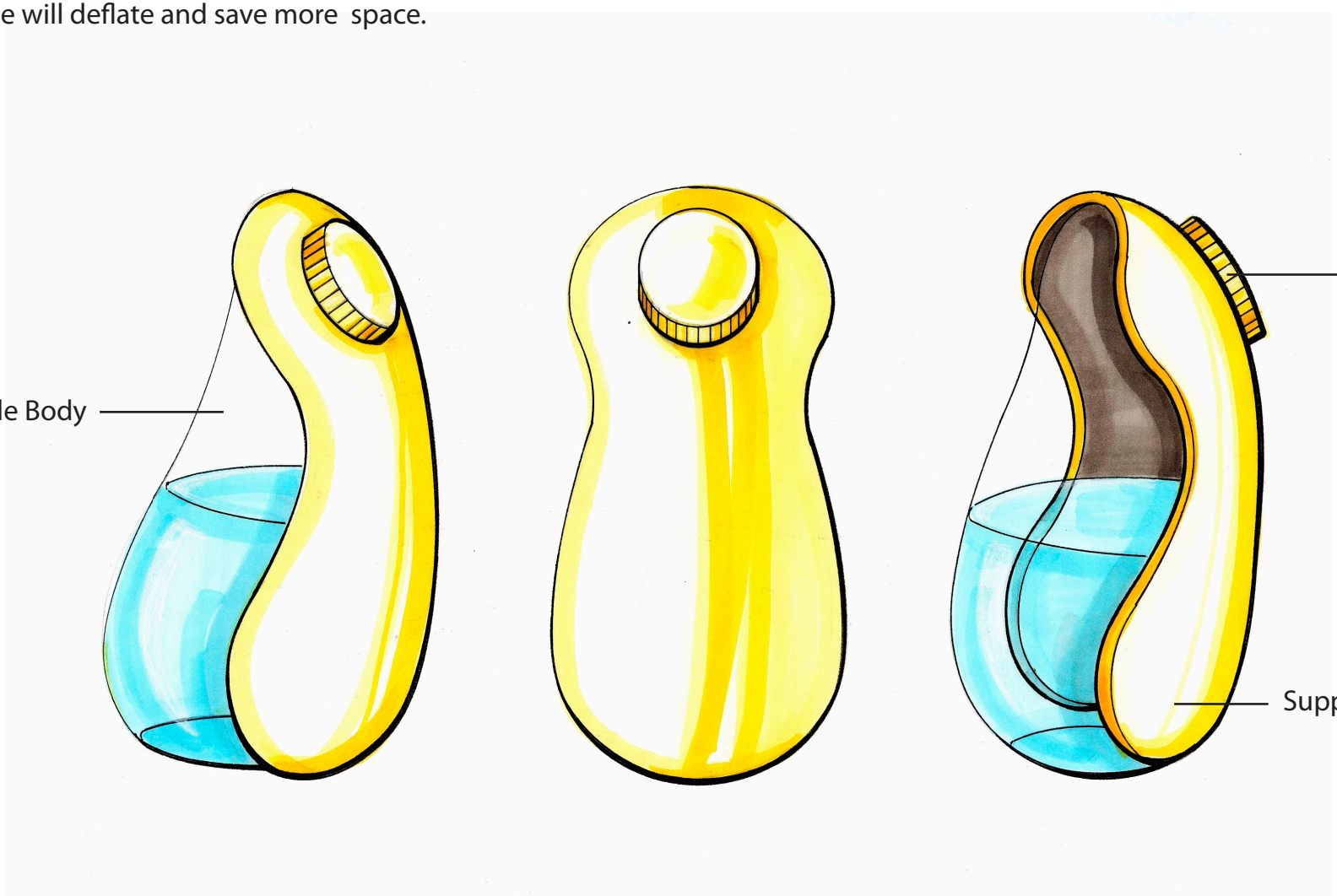


Form Ergonomics

To determine the dimension and form of the supporting shell, I built various full-size clay mock-ups. The challenge here was to balance the functionality and aesthetics so that users can hold it comfortably in hands.

Refined Concept III

Based on the form ergonomics study, I developed the Refined Concept III. The water pouch is fully attached on the supporting shell, and the bottle is washable and reusable. The curve design of supporting shell gives this bottle an elegant look and helps users to grip the bottle reliably and comfortably. Since the pouch is made of flexible material, when the bottle is empty, the body of bottle will deflate and save more space.



3D Rendering

Mock-up

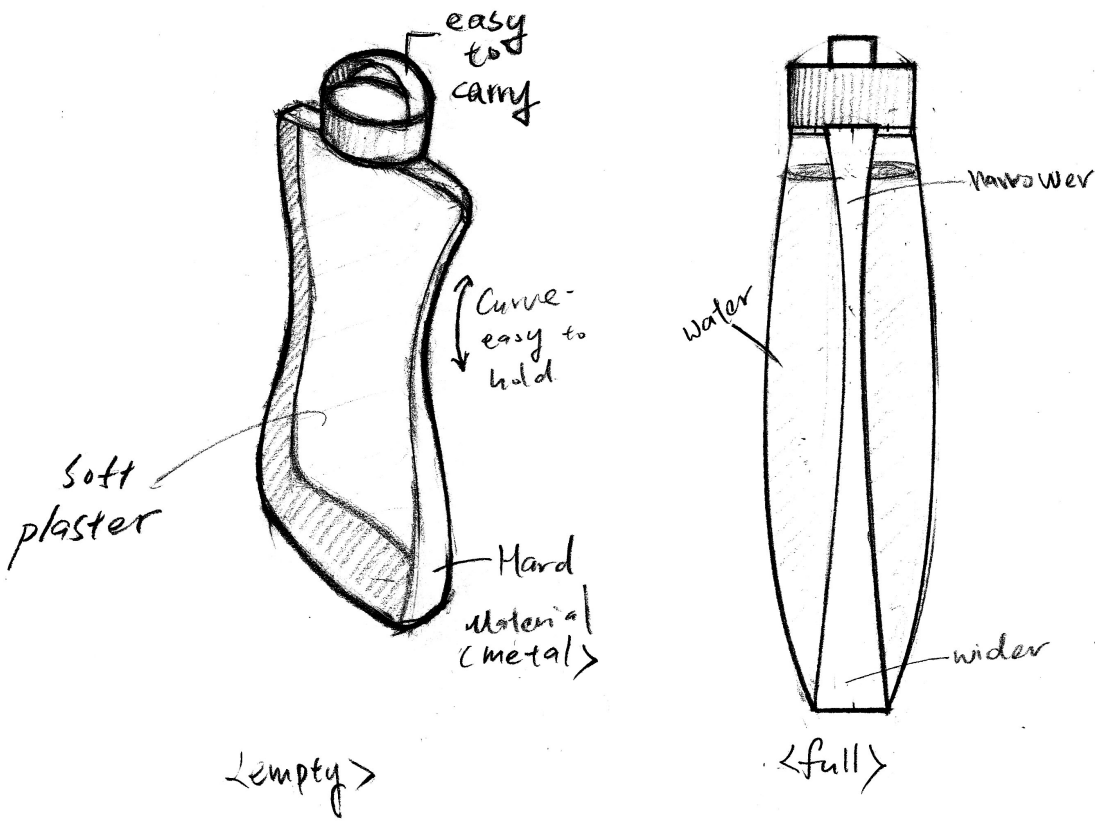


After making the mock-up, I found that there are cons which need to be overcome and improved:

1. The bottle mouth is not on the top but on the side of the bottle, so users have to drink water at a specific position.
2. The pouch is fully attached on the surface, so if the flexible pouch is damaged, the whole bottle has to be thrown away, and it will cause a waste of materials. It would be more sustainable if the water pouch can be replaceable.
3. In order to make the shell to be able to stand on it is own, the curve of the bottom of the shell has to be large enough, but it will occupy more space.

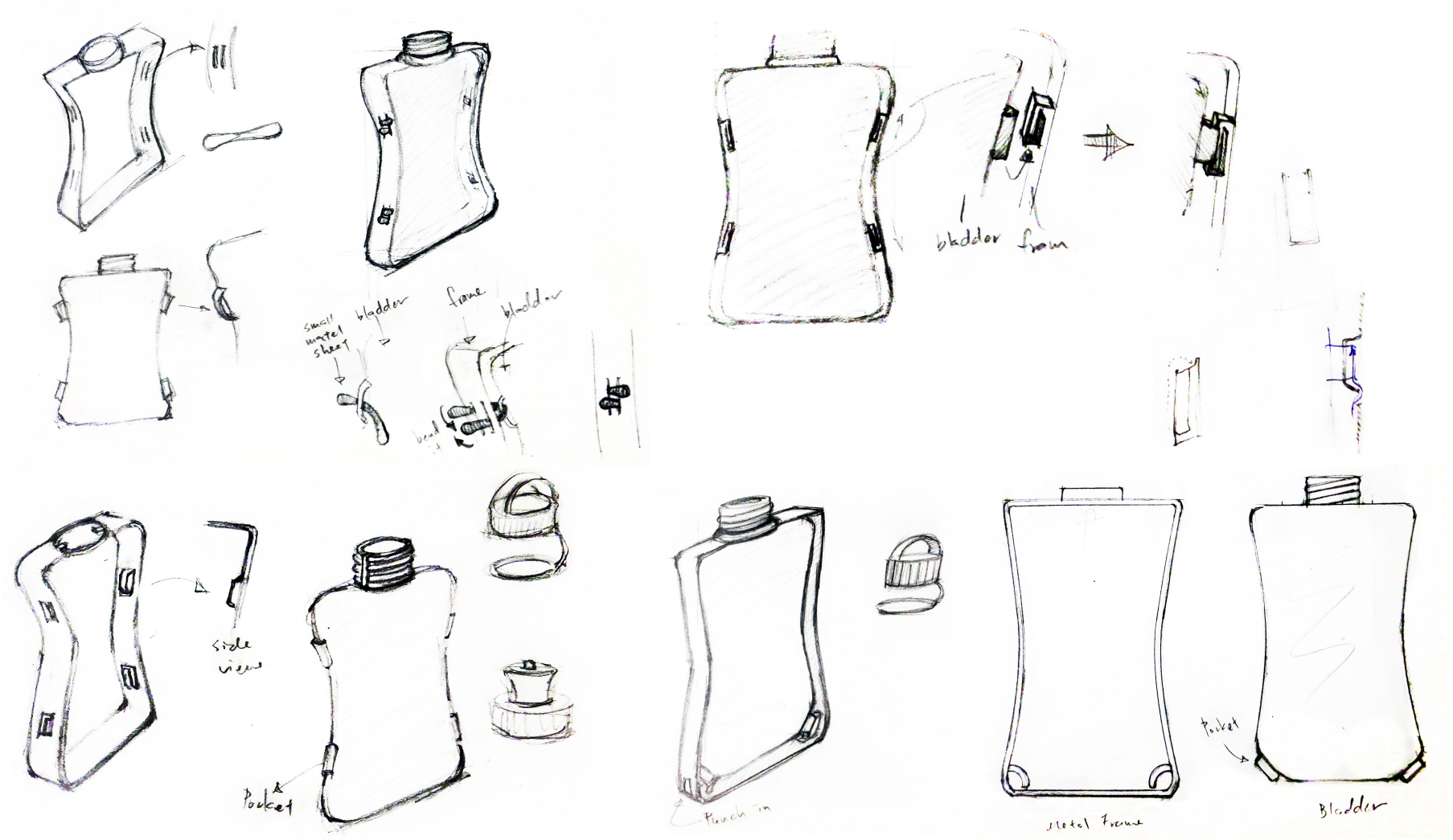
Refined Concept IV

To improve the cons of the Refined Concept III, the design of a flexible pouch with supporting shell is revised to be a **flexible pouch attaching with holding frame** so as to make the profile of water bottle more compact, and the mouth of bottle is no longer on the side but on the top of the bottle. Considering that some people have smaller hands, I designed the curved shape on the sides to make the middle part of bottle slimmer, so even children can hold the bottle easily and tightly. The loop cap is designed for the ease of users to carry or suspend the bottle. The mock-up made of wood and copper is for helping me to measure the actual dimension and to think further about design details.



Refined Concept IV

These sketches show various ways of how the water pouch is assembled and attached to the frame. In the beginning, I was thinking to place four hooks on the frame, and than I reduced to two hooks on the bottom of the frame to simplify the structure.



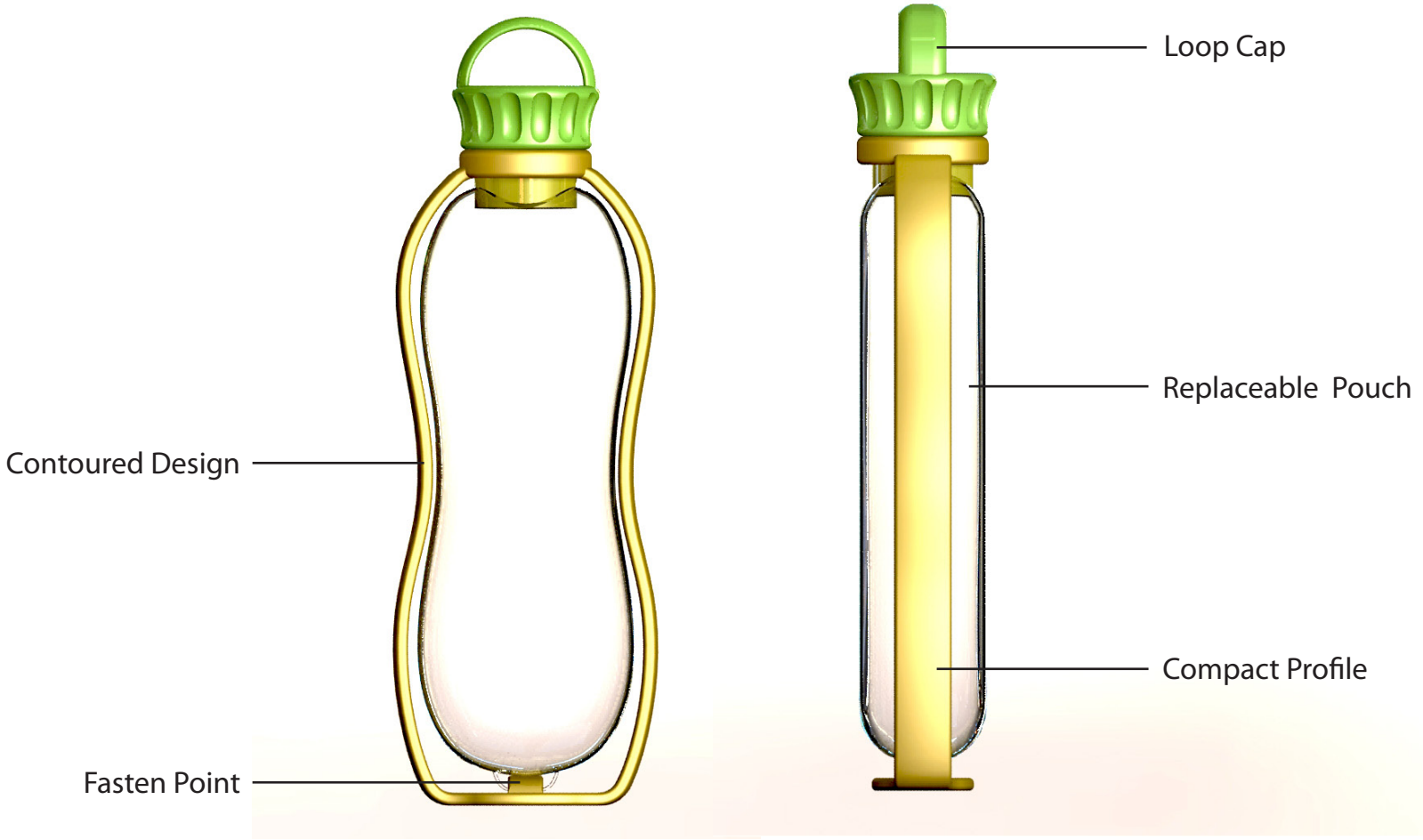
3D Rendering

Either the concept with four hooks or the one with two hooks is too complex for users to operate. The appearance of the holding frame is also too rigid and need to be revised to be more aesthetic.

Refined Concept V

Refined Concept V

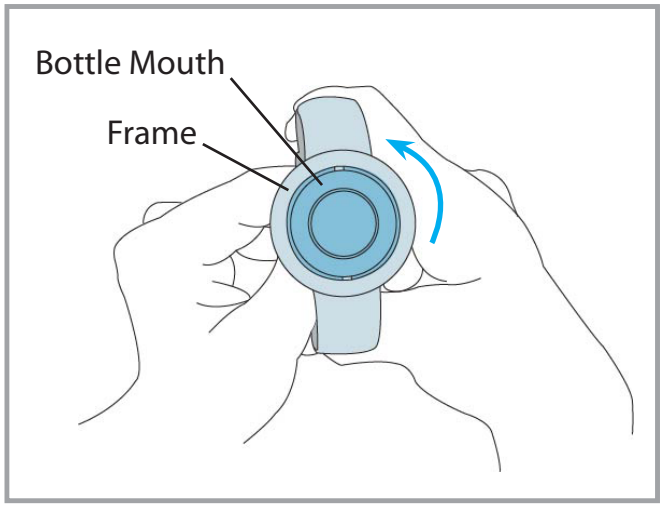
The appearance of the Refined Concept V had been revised to become more organic and elegant. The fasten points are reduced from two hooks to only one hook on the bottom middle of the frame. The bottom of frame is slightly wider so that the bottle is more stable to stand on it is own.



Refined Concept V

The components of the bottle:
holding frame, **pouch**, and **loop cap**.

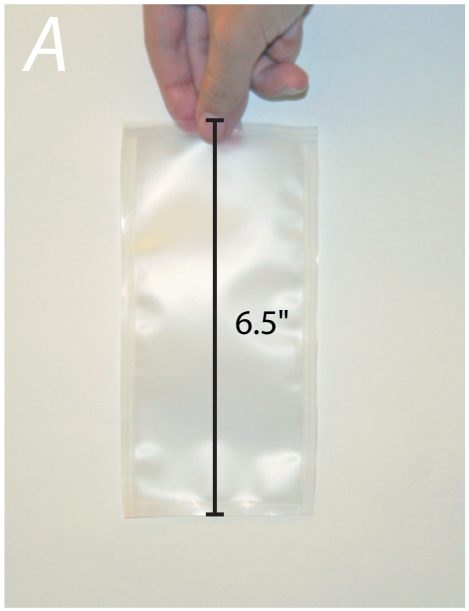
There are two projections on the opening of the frame and two vertical notches on the bottle mouth. When replacing and assembleing the pouch, users just slide the projection parts of the frame into the vertical notches on the bottle mouth, twist it anticlockwise, and then the pouch will be locked on the frame.

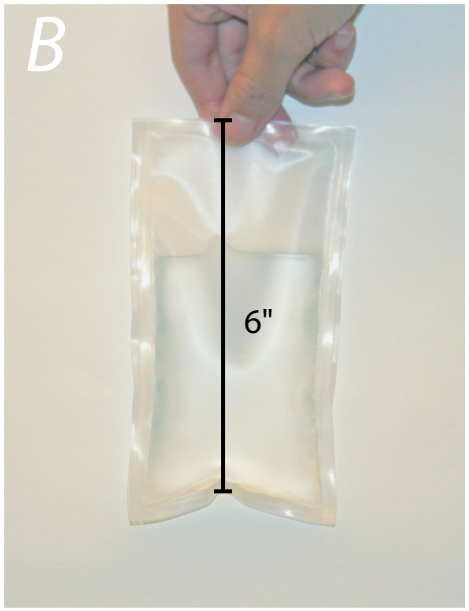


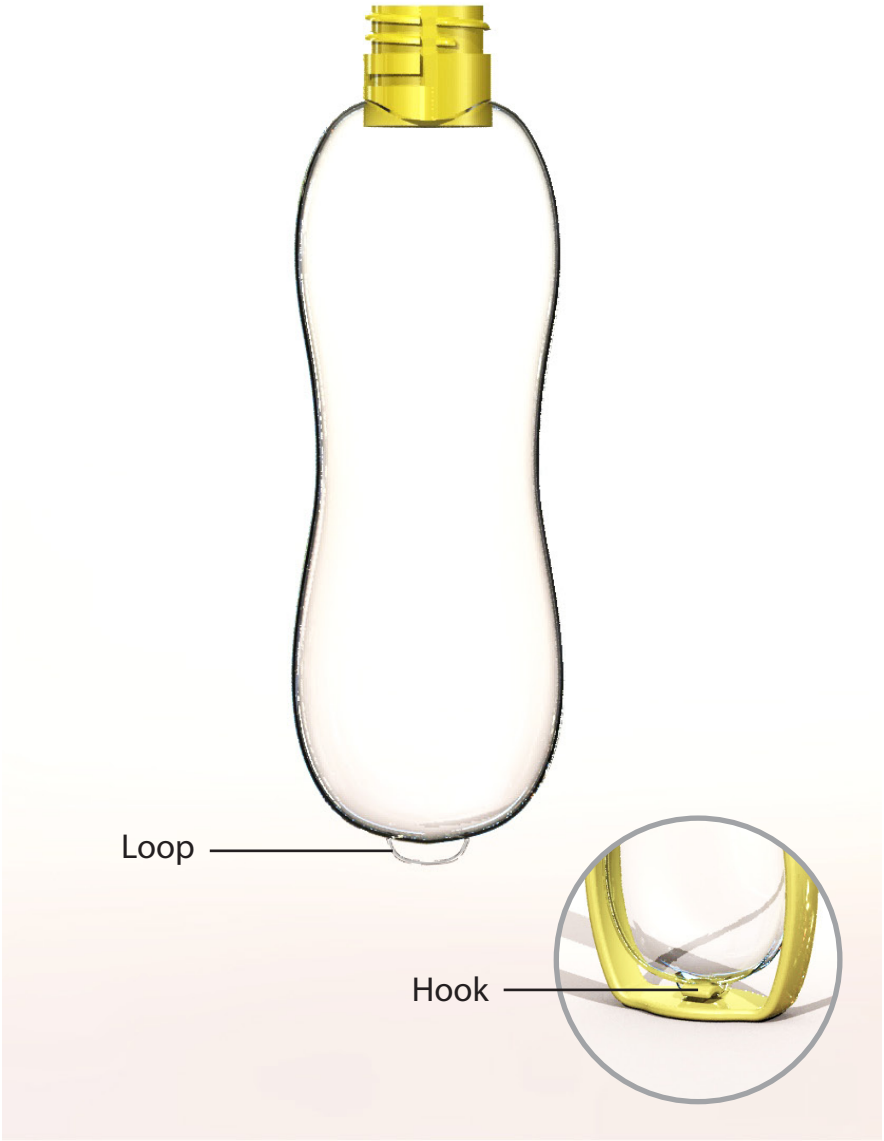
Refined Concept V

After twisting the pouch into the opening of holding frame, users need to clasp the loop on the bottom of pouch to the hook on the bottom of frame, and then the pouch will be attached on the frame tightly. Since the pouch is made of flexible material, when it contains water, the length will shrink a little bit. The more water the pouch contains, the tighter the pouch attaches on the frame.

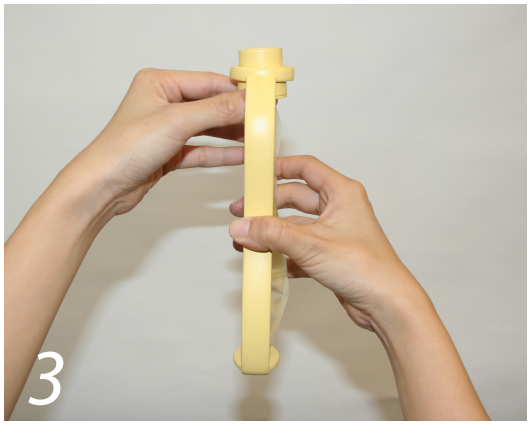
In order to prove this point, I did an experiment. I made two plastic pouches with the same dimensions. One was empty (Photo A); another one contained water inside (Photo B). When the pouch was empty, the length was 6.5", but when it contained water, the length became 6". It proves that the length of water pouch will slightly shorten to increase the grip of the loop hooking on the frame when the pouch contains water and inflates.







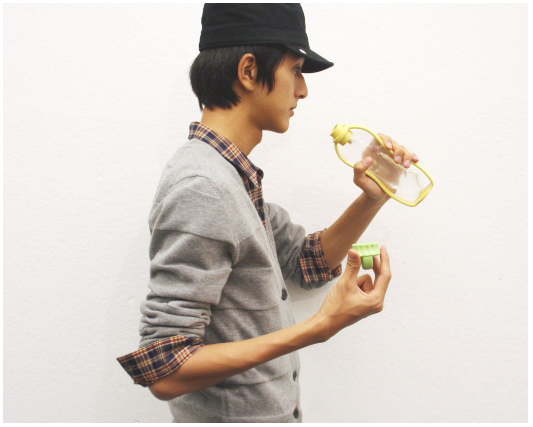
Procedure of Assembling The Pouch



The complete prodedure of assembling the pouch is as follow:

1. Hold the frame and pouch. The frame and pouch should be vertical to each other, as the photo shows.
2. Slide the bottle mouth into the opening of the frame.
3. Twist the bottle mouth anticlockwise.
4. Clasp the loop on the bottom of pouch to the hook on the bottom of frame.
5. Screw the cap on tightly and done.

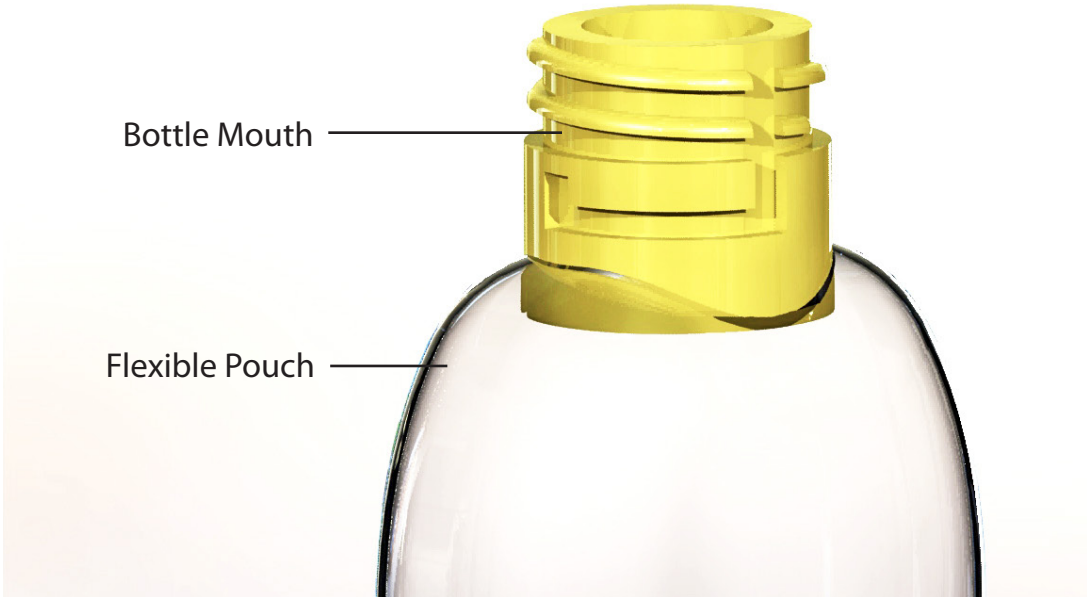
User Scenarios



The compact and stylish appearance of the water bottle can fit in many occasions such as working, traveling, party, or any special event. With a slim svelte design, the water bottle can be placed into smaller space, such as pockets and handbags, to carry around and take up less room than any ordinary reusable water bottle. Users can also carry the bottle with the loop cap or insert a strap through the loop to secure the water bottle in place, especially when biking or climbing.

Pros and Cons

This concept certainly increases the portability of water bottle. The deisgn of the frame-like structure and the flexible body of bottle can reduce the use of materials through production compared with most water bottles in the market, and it is also a compact and lightweight solution which is ideal for carrying in different occasions and fitting in narrow space. Nevertheless, the structure of the junction of the mouth and the pouch, that it is permanently sealed, can create problem in recycling process because it increases the difficulty to separate two different types of polymers. Currently different materials, even different types of plastics, cannot be mixed together during recycling; otherwise, one type of material may contaminate the other, and it will reduce the quality and value of the recycled materials. To prevent contamination, a structure like this requires a relatively high expense and extra efforts to seperate the materials before processing. Under these circumstances, there is a large chance that a design like this bottle will be sent to a landfill site directly by recyclers and become negartive impact to the environment. Minimizing the environmental cost at the end of its lifecycle, the structure of the junction of the mouth and the pouch has to be revised and to become more recycle friendly.



Chapter 4

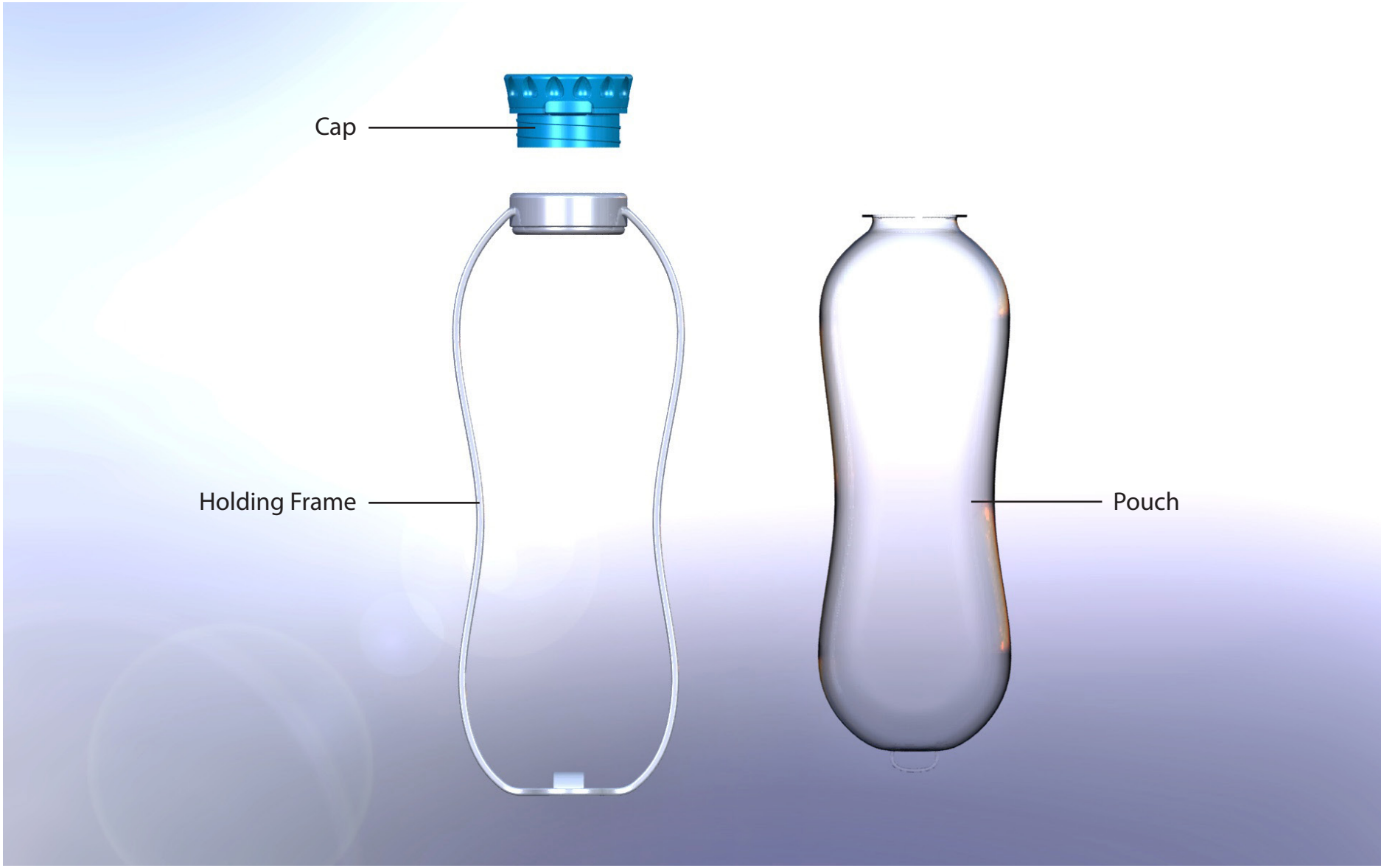
Final Concept:
The Ogee Soft Bottle

Ogee Soft Bottle

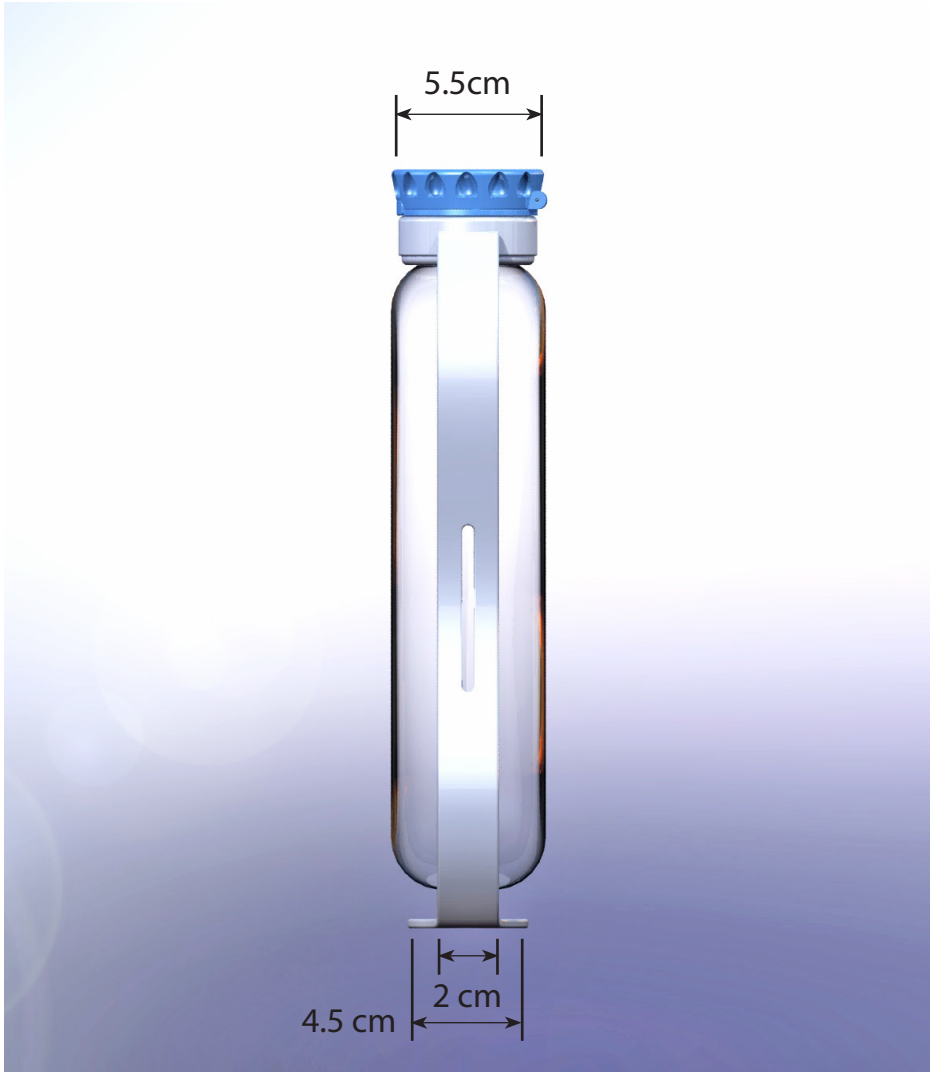
The appearance and dimension of Ogee Soft Bottle do not have large differences when compared with the Refined Concept V, but the structure is improved to be more sustainable, and the procedure of assembling the pouch is simplified as well.

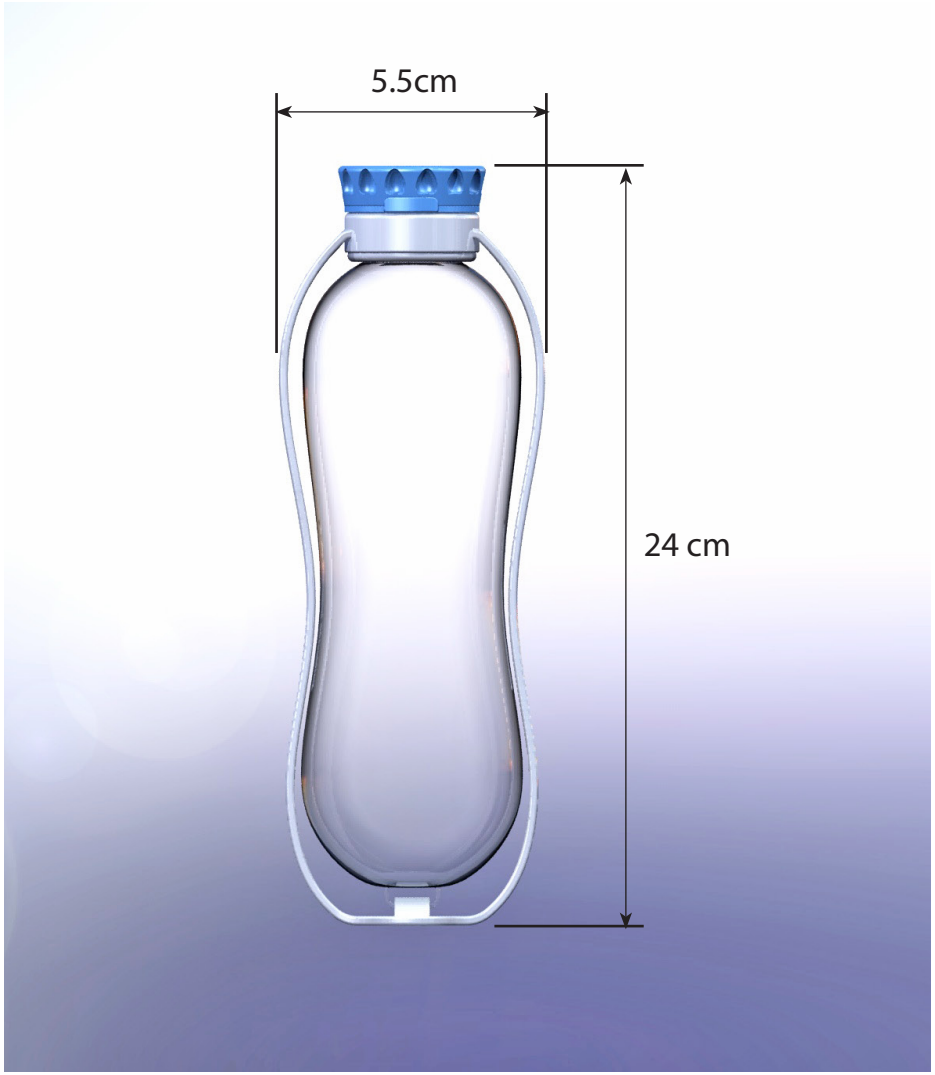
This bottle contains three components: **holding frame**, **pouch**, and **cap**. These components which are made of different materials can be completely seperated when recycled, so the whole design is a recycle-friendly product. About the functionality, I combined the cap and bottle mouth together. Users can operate the cap by simply pushing a button. This design makes it perfectly one handed, especially for users who are biking or driving cars. In addition, users do not need to concern about losing the cap easily. The curved shape of the frame is designed to fit in both small and big hands. The cutting on the frame makes it less slippery when wet. The flexible pouch is replaceable, so users can prepare several ones at home. If some days users run out of time to wash the pouch out from the day before, they can clean it later and replace another pouch immediately. Other than the pouch, both the cap and the frame are made of durable plastics and can be easily replaced if damaged or lost. The goal of my design is to create a long-lasting product that is suitable for whole families and can be used repeatedly without having to re-purchase it.

Components



Dimension

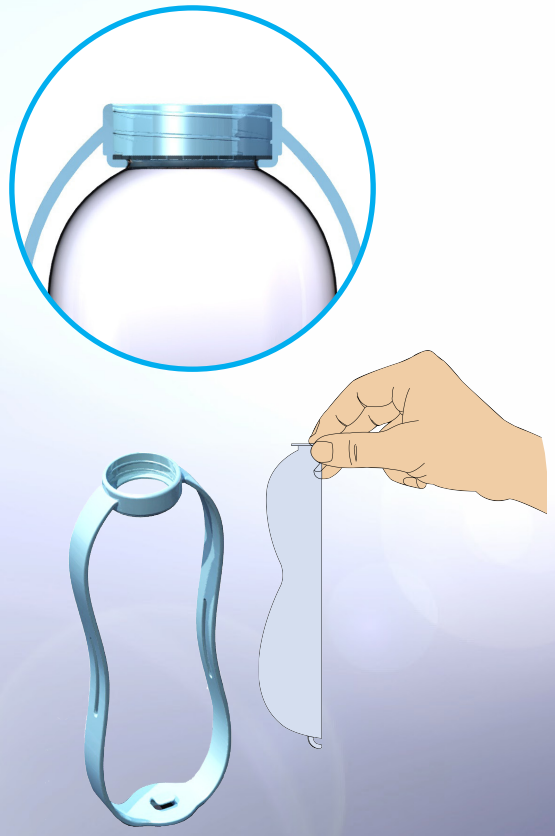




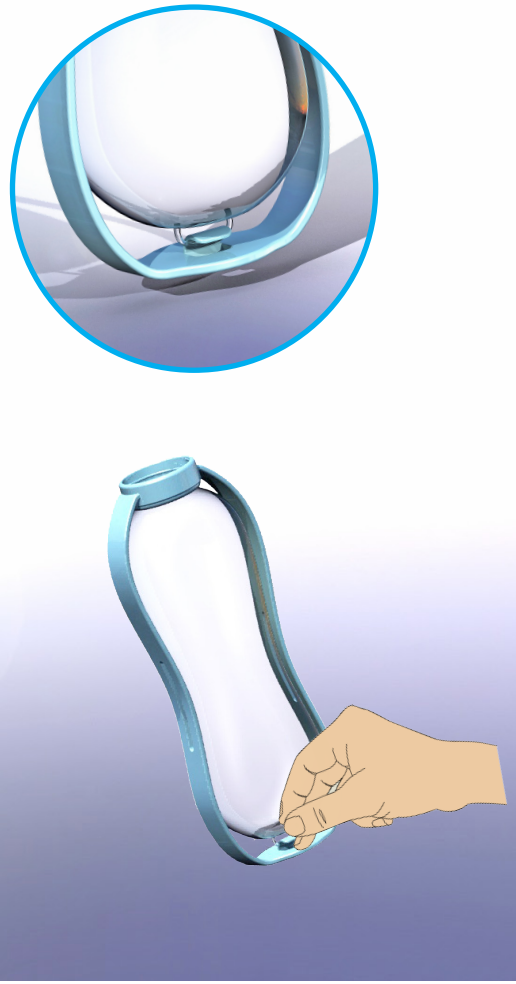
The dimension is 5.5 cm x 10 cm x 24 cm. The width of the frame is only 2 cm. Even the widest part of the frame, the bottom of the frame, is only 4.5 cm. The compact design makes the bottle thin and lightweight but stable enough to stand on it is own.

Procedure of Assembling The Pouch

1. Fold the pouch lengthwise and place the pouch into the opening of the frame. The edge of the pouch will rest on the rim of the frame's opening.

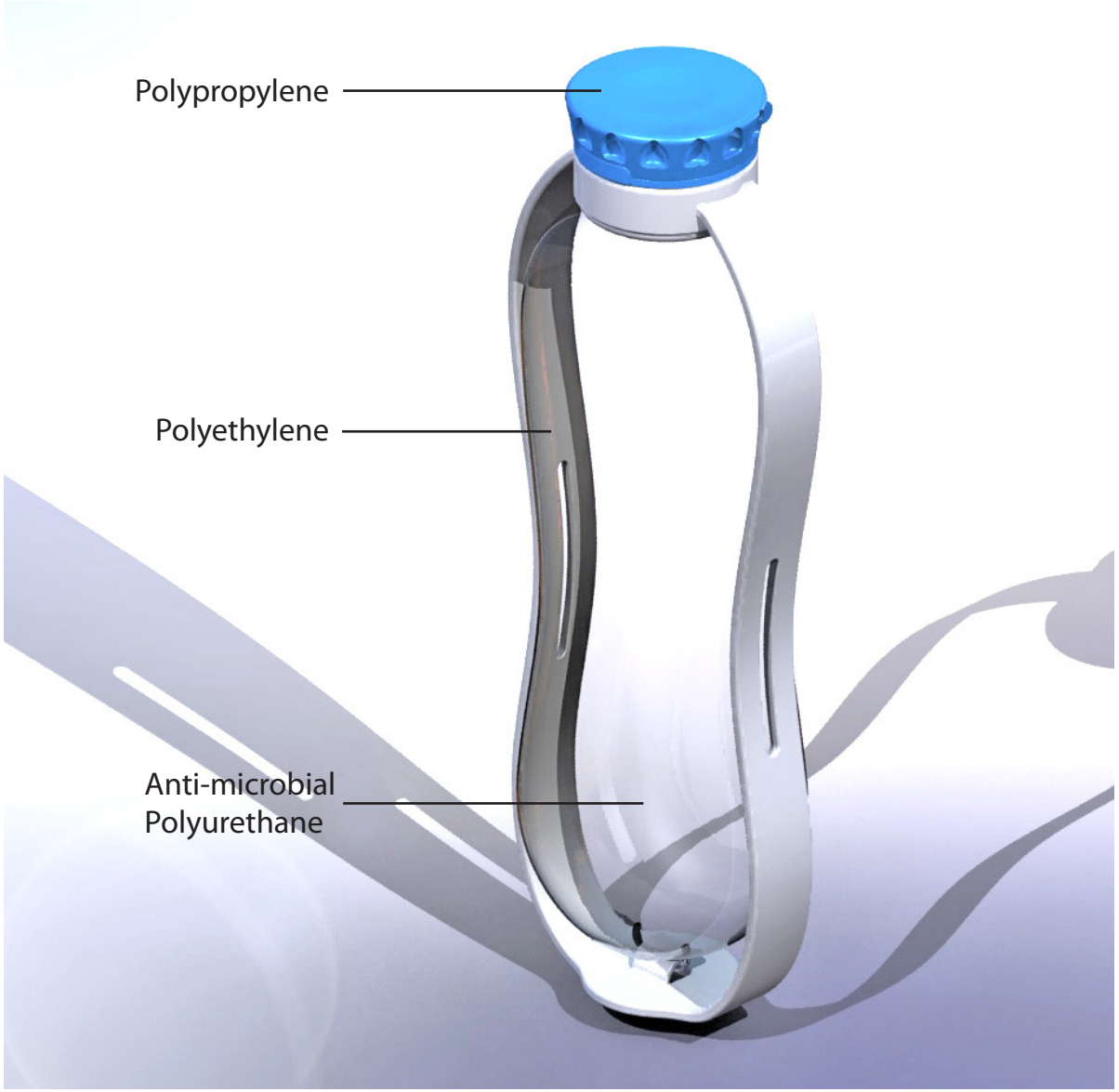


2. Clasp the loop on the bottom of pouch to the hook on the bottom of frame.



3. Screw the cap on tightly to stable the pouch and done.

Materials Attributes

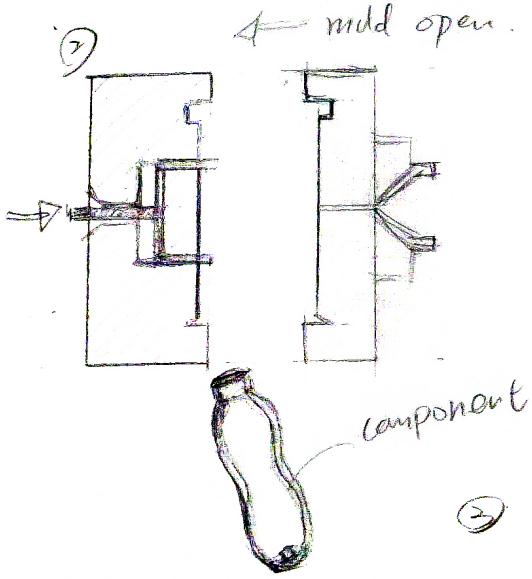


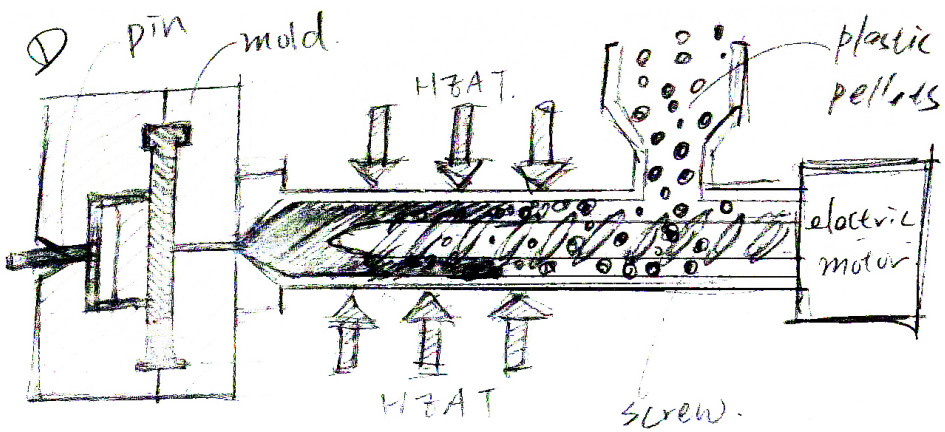
Rather than using bioplastics, which is currently not accepted by most recyclers and cannot biodegrade in landfill sites, or metals, which requires mining for raw materials through production and will consume numerous energy and emit greenhouse gas emissions, the Ogee Soft Bottle is mainly made of plastics that it is durable, lightweight, and low-cost and can be fully recycled and accepted by most curbside programs.

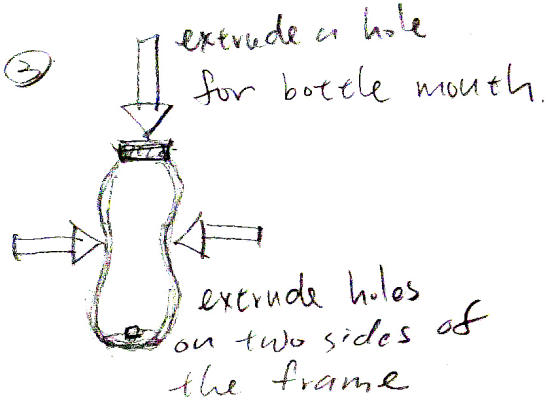
The cap is made of **polypropylene** (PP); the frame is made of **polyethylene** (PE). Both of these materials are easy to manufacture, safe to contact food, and durable to be used. Especially Polyethylene has significant good stiffness and impact-resistance. It is a considerably sturdy material choice for this permanent holding frame. The flexible pouch is made of FDA approved **anti-microbial polyurethane** (PU). It is also the standard material for hydration bladders in the market. This material can be 100% odor free, taste free, microwave safe, freezer safe, and UV stable; therefore, this is a safe and durable material which can be repeatedly used as a water container.

Manufacturing Processes

Both the cap and the frame will be manufactured through **injection molding**. Injection molding is predominately used for thermoplastics such as acrylic, polypropylene, and polyethylene. The process involves applying plastic in the form of pellets or granules from a hopper into a heated cylinder which contains a screw. The screw mixes and melts plastics to transform from a solid state to liquefied state and finally injects it at high pressure into a water-cooled mold cavity. Once the part has solidfied, the mold then opens, and pins will eject it to remove the finished part from the mold. The process is not only suitable to produce highly complex parts. It is also an efficient and cost effective manufacturing process that can lower the price of the water bottle in the market. The Ogee Soft Bottle therefore will be affordable to all who need it.[63]

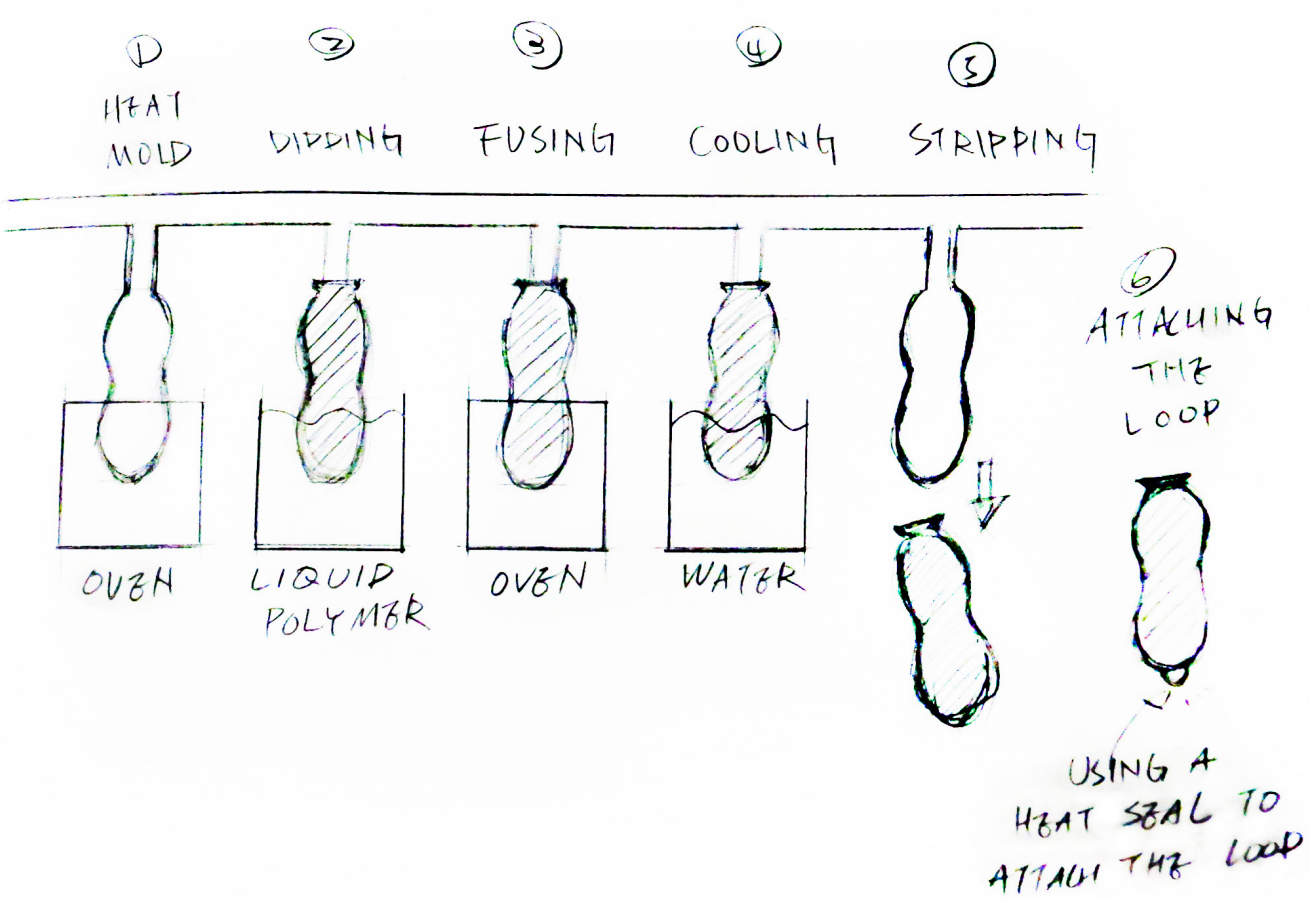






Manufacturing Processes

The pouch will be produced through **dip molding**. Dip molding is a process in which a heated mold is dipped into a material that has been melted to form a layer of coating. The mold is then extracted from the molten material and goes through a curing or cooling process. Once the newly formed part is cured, it can be peeled off as a finished part. Due to the nature of the process, it is limited to soft materials and parts that can be stretched over the mold, such as polyurethanes, latex, and PVC. The speed of manufacturing is varied depend on how complex the mold is. Since the shape of the water pouch is simple, the manufacturing speed can be significantly fast. Furthermore, it is a highly cost-effective manufacturing process as well to manufacture the pouch.[64]



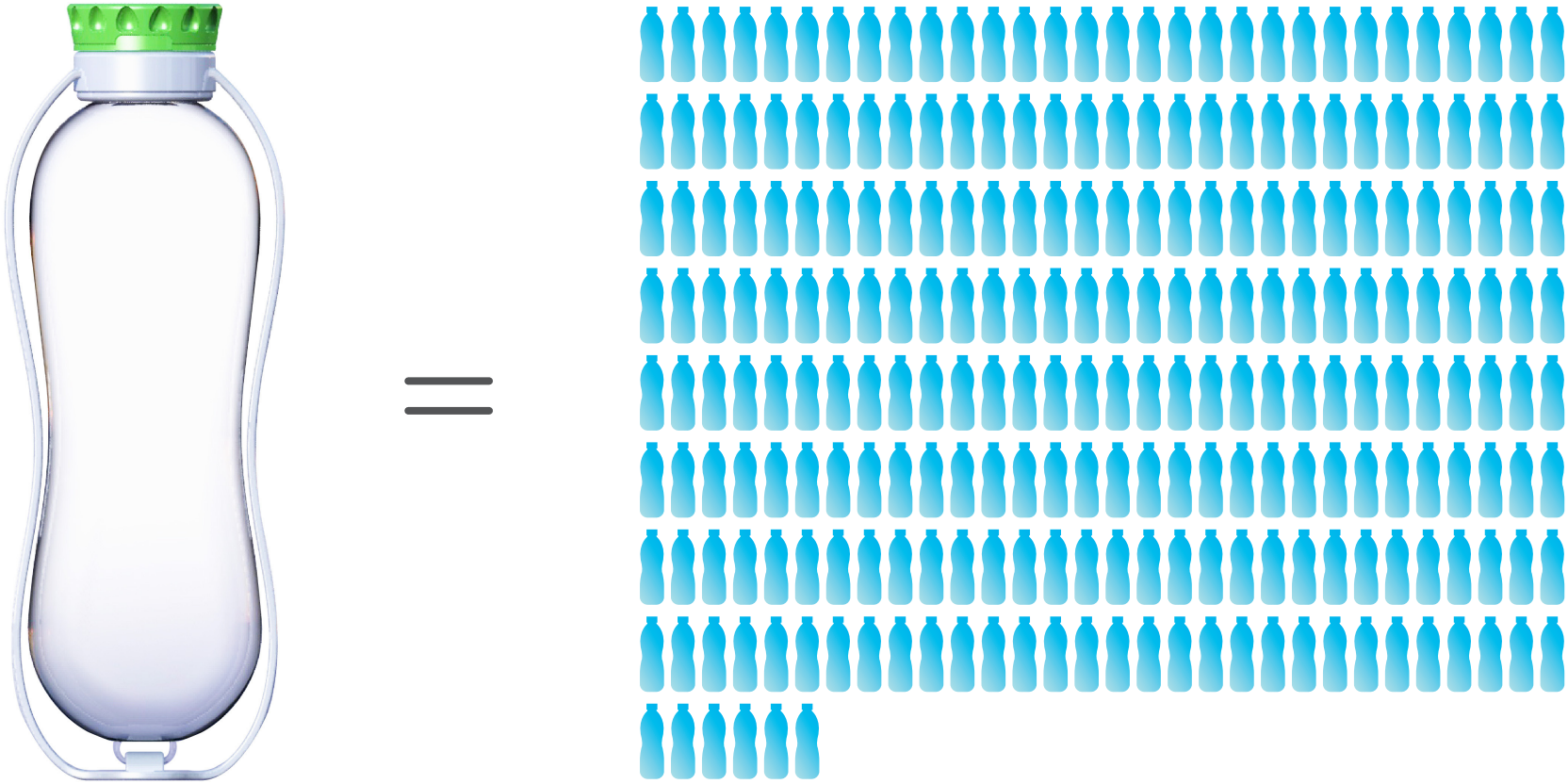
Color Variety

This image shows color variety of Obee Soft Bottle. Users can choose caps with different colors to suit their own personal tastes or to fit in different occasions. Furthermore, each of family members can choose different color as his or her personal identity.

User Scenarios

Result & Practice

With only about 4.5 percent of the world population, Americans consume roughly 60 percent of the world's water bottles. In the United States alone, if everyone could build a habit of drinking tap water and carrying a reusable water bottle instead of purchasing bottled water, approximately an average of 246 PET bottles of 500ml would be saved per year by each person.[65]



Result & Practice

For the convenience of acquiring a bottle of fresh water anytime and anywhere, it consumes numerous natural resources, causes unnecessary impacts to the planet, and depletes the fundamental human right of the poor to have access to clean water. The water it cantains may even harm the health of the public. The popularity of bottled water does not demonstrate a result but a phenomenon that is relevant to a series of choices of what people value and how they measure these values. As long as people can acknowledge and recognize the real price behind the prosperity of the bottled water industry and start to alter the path of development by adopting sustainable alternatives, it is anticipated that bottled water will not be an issue one day. I hope that the Ogee Soft Bottle can bring a more portable, more sustainable, and more pleasant alternative for people who used to be consumers of bottled water. By cultivating the habit of carrying a reusable water bottle, everyone can contribute to sustainability and a better future for the generations to come.

Notes

Preface

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