

## Analysis of Water Use for Water Bottle Production

Lisa DiNicolantonio, Emma Hansen-Smith, Sloane Rice

### **Abstract**

The bottled water industry utilizes large quantities of water in the production of individual plastic water bottles, causing the manufacturing process to generate excessive amounts of wasted water. This generates a serious problem for California and the current need to reduce water use while improving water conservation efforts. In order to discover the water use efficiency of different types of bottles, conversion factors were used to consolidate the data collected for each type of bottle in order to conduct a comparison. Despite finding that reusable water bottles require more water to be manufactured, it was determined that single-use water bottles are the less efficient source of water compared to tap water and reusable water bottles. This is due to the average lifespan difference between these different types of bottles. When calculating the data, limitations were faced due to the amount of initial data that was available. It was impossible to find data on how much water is required to actually form the different types of bottles, resulting in calculations done to discover the volume of water required to produce the amount of plastic or steel necessary for each bottle. However, this still serves as a good proxy because the production of the plastic and the steel itself is what takes up the most water in the process. These calculations can be used to inform citizens about water use in manufacturing, which tends to be overlooked when trying to conserve water.

## **Introduction**

California is in the midst of a severe water crisis, forcing residents to greatly reduce their water use by altering behavior and consumption use. Water is a highly integrated resource required during the manufacturing processes and packaging of items used in everyday life. The hidden water use needs to be evaluated for people to realize the amount of water that is actually being used. Major uses of water, in terms of packaging, are single-use plastic bottles. The main use of single-use plastic bottles is for bottling water for resale. If California residents started integrating drinking water use along with their other water uses, it would cause an increase in the support for the reduction of water consumption. This would allow residents to make better decisions about how to effectively reduce their water usage, which is becoming increasingly important in California due to the mandatory 25 percent urban water reduction that was enacted by the office of the Governor.

There are two different agencies responsible for regulating the water used as public drinking water and as bottled water. The Environmental Protection Agency (EPA) is responsible for regulating the quality of tap water; while the Food and Drug Administration (FDA) oversees water used by bottled water companies (Goodman, 2009). Since these two sources of water, tap and bottled water, are regulated by different agencies, there are different regulation standards generated. Compared to the EPA's protection of tap water, the FDA has a less stringent level of safety and consumer protection over bottled water (Waxman and Markey, 2009). Under the regulation of the EPA, the public drinking water is required to be tested by certified laboratories, report all violations in a timely fashion, mandate that public water systems provide consumers with reports about the water specifying the source, contamination and compliance with regulations (Goodman, 2009). The FDA regulates bottled water as food, not allowing the water

to be tested by certified labs or report violations; the bottled water companies are also not required to state water treatment methods, water source, or presence of contamination (Goodman, 2009). Overall, the state requirements present to safeguard bottled water typically exceed the FDA's, though the requirements are generally less comprehensive than the state requirements in place to safeguard tap water (Waxman and Markey, 2009). Beyond the differences in the actual water used, single-use water bottles contribute to waste that ends up in the landfill. Even though the waste that water bottles contribute overall is minimal, it was discovered that of the water bottles produced in the US in 2006, three-quarters of water bottles were discarded instead of being recycled (Waxman and Markey, 2009). Also, the energy used during the production and consumption of bottled water is far more energy-intensive than the production of tap water (Waxman and Markey, 2009). Single-use water bottles are less regulated than tap water, while also increasing the probability of waste. Besides the amount of water used in production, these aspects are important to consider, as they each are associated with the use on single-use water bottles.

### **Objective**

The main objective of this report is to investigate the amount of water that is used in the production of a liter size single-use plastic water bottle and compare that with the water used to create a liter size reusable stainless steel and reusable plastic water bottles and determine the level of water efficiency of each manufacturing process. This project is divided into three main tasks: (1) collecting data for plastic, reusable plastic, and reusable stainless steel water bottles, (2) comparing the water demanded in the manufacturing process of each bottle, and (3) determining the total amount of water saved by using the bottle that conserves the largest amount of water while considering the total life of the different water bottles.

## **Hypothesis**

It is predicted that the amount of water used in the production of single-use plastic water bottles will be greater than the amount of water used to produce reusable stainless steel bottles and reusable plastic bottles when considering the total life of a reusable water bottle. It is also predicted that a higher percentage of single-use water bottles are discarded compared to reusable stainless steel and plastic bottles because of the fact that a reusable bottle has a higher average lifespan.

## **Data Sources**

To collect data, various online reports were used to help calculate different statistics. Calculations and reports to determine the water used in the production of single-use water bottles itself were already available, but that data did not take into consideration the amount of water it takes to produce the plastic, which uses the largest amount of water in the development process. There were no previous reports available to determine the water requirements for the production of stainless steel or plastic reusable water bottles, so the only data collected is for the amount of water it takes to produce the steel and plastic, but not any data for making the bottle itself.

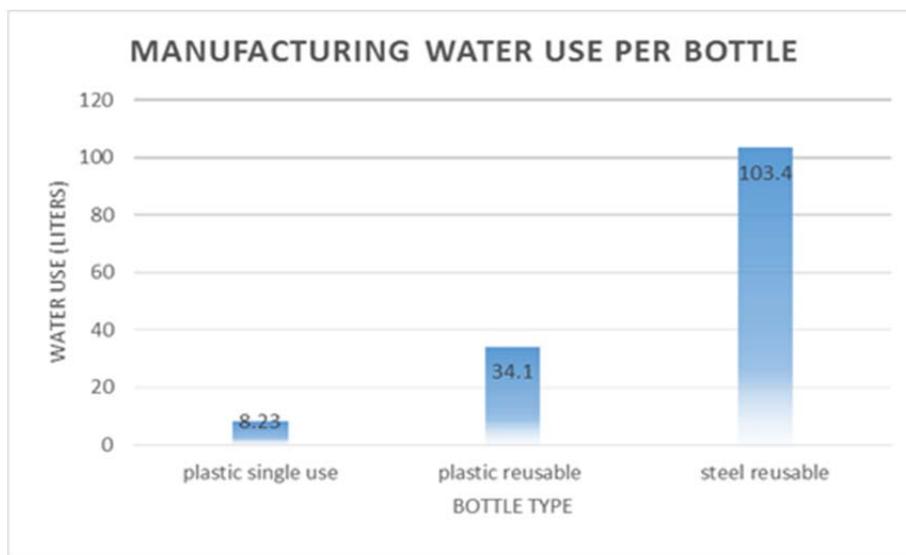
## **Methods and Assumptions**

In order to calculate the data for comparison, conversion factors were used to compare the calculated data. To make the calculations, it was assumed that the average weights for one liter water bottles were 6oz. for a reusable plastic water bottle, 14.1oz. for a reusable steel water bottle, and 1.45oz. for a single-use plastic water bottle. Further assumptions were made figuring that it takes 90.8 liters of water to produce 16oz. of plastic and that it takes 117.34 liters of water to produce 16oz. of steel (Merchant, 2009). The final assumption was that the entire weight of the water bottle was either steel or plastic and did not consider the material the cap was made out

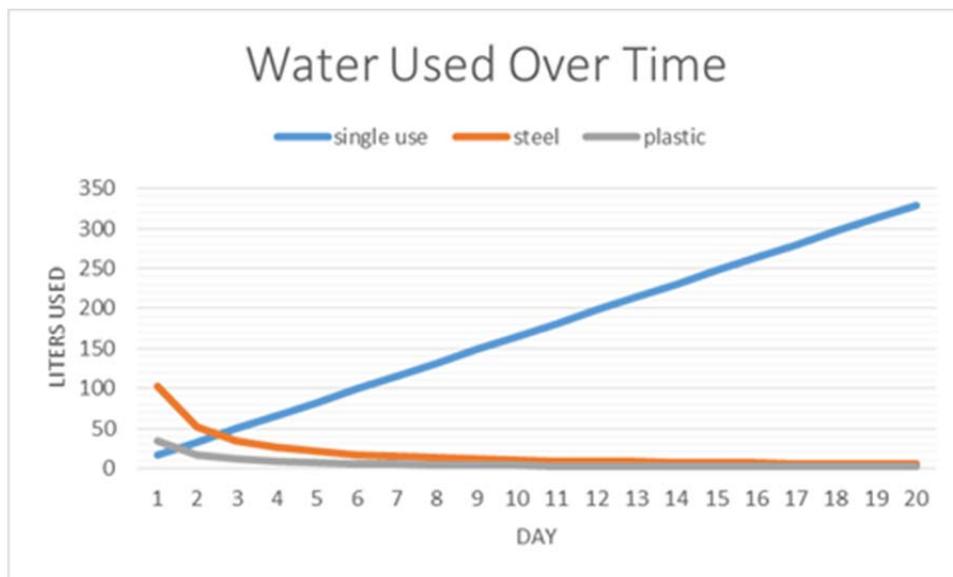
of. The amount of water used when the bottle itself is being manufactured was not considered. The only water use considered was the amount of water that is required for the amount of steel or plastic in the bottle because data to calculate how much water was actually required to make the final bottle was not found.

### Calculations and Results

To calculate the data for the each water bottle the amount of water needed to process steel and plastic was calculated and then converted to find the average weight of a liter sized stainless steel bottle that was approximately 14.1 oz. The final calculations determined that 103.4 liters of water were required to produce a liter sized stainless steel water bottle. Along with this, the average plastic reusable water bottle was determined, which is approximately 6 oz. takes about 34.1 liters to produce. In comparison, a single-use water bottle only required 8.23 liters of water to manufacture each bottle. That correlates to roughly 12.5 single-use bottles for every reusable steel bottle and about 4 single-use water bottles for reusable plastic water bottle. This data can be summarized with the following graph:



This graph shows there is a significant difference between the water use of manufacturing single-use plastic water bottles, reusable plastic water bottles, and steel water bottles. Single-use water bottles are much more efficient to produce than the reusable bottles. However, this does not take into account the lifespan of the bottle. It is not recommended to use single-use water bottles more than once because the plastic can form cracks that hold bacteria, which can be harmful to humans. The continual use can cause a physical breakdown of the plastic, possibly creating cracks, which can harbor bacteria and cause health risks. The water in the bottle can also face bacterial contamination, unless the bottle is gently washed before being reused (Leising et al., 2007).



Plastic and steel reusable water bottles have a much longer lifespan and are designed to be used for years. The graph above illustrates that over time, the reusable water bottles are much more efficient than the single-use water bottles. This is because there is no new water input required for each use of the reusable water bottles compared to the single-use water bottles, which require

a new input of 8.23 liters for every one-liter water bottle. So overall, single-use water bottles are much less efficient with time compared to reusable water bottles of either kind.

## **Conclusions**

It was found that our hypothesis is incorrect in terms of the amount of water that is used for making a single water bottle but is correct when analyzing the amount of waste generated because we found that reusable bottles create less waste. Based on further research and calculations, the findings show that, in the long run, the reusable water bottles are used for a much longer period of time and ultimately end up using less water and result in the formation of less waste than single-use water bottles.

These results could be used to inform companies such as Nestle, Aquafina, and Dasini which produce single-use water bottles, along with reusable water bottle producers such as Klean Kanteen and Contigo about how effective their products would be at helping conserve water compared to others. These companies would benefit from knowing this information in order to adjust their manufacturing processes and help in the reduction of water consumption in comparison to other companies. This has the potential to inspire individual companies to improve their system making them more marketable and cost effective. The results would be valuable information for the state of California, allowing the state the possibility to distribute the findings to enlighten California residents one easy way to reduce their water consumption. This would be immensely valuable since many of the water bottling plants are located in California and the water used in manufacturing is mainly derived from California water supplies.

### **Recommendations/Limitations**

One major limitation associated with this topic is the potential for biased information to be reported. Supporters of the different companies will advertise information to maximize profits, with a majority of the data available from companies like Nestle. These companies use their website to report their water use and promote the demand for reusable bottles over single-use bottles. It has been a challenge finding unbiased information that is useable for this study. Most websites report very similar numbers, but depending where you look, there is some variation. To overcome this, it will be necessary to find a credible, unbiased source, or take the average of the data found and estimate the water use values. Another limitation to this topic is the convenience aspect of single-use bottles for events such as road trips or music festivals, where there may not be a fill-up station for a reusable water bottle. There are many people who will not be willing to take the risk of running out of water and will continue to purchase single-use plastic water bottles.

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