**A TOOTH’S GREATEST FEAR…. WATER!**

By Danielle Sheehan, 3 Period

**ABSTRACT**

Many people are using water with a variety of contaminants in them to brush their teeth with. However, I was faced with the obstacle of determining whether or not these teeth were actually being cleaned with the contaminated water.

Experimenting, I set up a variety of teeth in saliva solutions in an incubator of 96F, giving the impression of being in a mouth. I then three times daily brushed the teeth with waters of different concentrations for three weeks. However, at the end of the three weeks I saw no damage that had been done to the teeth’s enamel.

In conclusion, I realized that this could be due to a variety of reasons. The most predominate reason was that the EPA, United States Environmental, was able to come up with a list of the contaminants found in water. Although there are many hazardous effects due to the contamination of water, none of the effects resulted in the destruction of teeth. It was also determined brushing teeth used little water, so the teeth are exposed to little contaminants, lessening the chance of damage done to the teeth. Therefore, it is safe for people to continue to use their tap water while brushing their teeth and not worry about damage done to their teeth due to the variety of contaminants that may be found in the water.

**ACKNOWLEDGEMENTS**

My mother was there to support me and find alternatives to problems that arose.  She helped me to gain the teeth and allow the experiment to be possible.

Mr. Theil, my AP biology teacher, also had a large part in helping me to complete the project. He provided me with continual assistance and was always there to answer any questions that I might have. He also provided me with essential tools, such as the camera to get close up pictures of the teeth. He continually dedicated his time to helping me out with any problems that I would encounter and would always do his best to offer solutions.

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**Introduction**

*(Problem/Hypothesis)*

Water has always been used while brushing one’s teeth to help clean off the enamel, surface area, of the teeth. However, naked to the human eye, exist a variety of contaminants in the water. These wide ranges of contaminants that have been discovered by the EPA, United States Environmental Protection Agency, in water can be very harmful to the human body. There are also a variety of different types of water that people use, each containing a different amount of contaminants. People are subjected to this water everyday through the use of tap water to brush one’s teeth. In my experiment, I am testing to see if the water with a greater amount of contaminants will build up on the teeth and tear away at the teeth when brushed up against by the use of the toothbrush. This knowledge will affect what water people use in brushing their teeth in order to insure not damaging their teeth while brushing them.

With the continual exposure to the contaminants and the build up of calcium carbonate on the teeth’s surface due to the bacteria, I think that the teeth are exposed to greater harm when there is a high concentration of contaminants in the water that is used to brush one’s teeth with. The concentration of water with greater amount of contaminants will build up on the teeth faster than they can be washed away and will result in damaging the teeth. Therefore, in my experiment, if the water with greater amount of contaminants damages the health of teeth at greater effects than the water with less contamination, then the teeth brushed with high concentrations of contaminated water will show a build up of contaminants on the teeth and express greater amounts of damage to the teeth.

**Review of Literature**

According to Tom Condon, a Microbiologist ([http://www.water.com/learn\_about \_water/hs\_lrn\_art013\_p01.asp0](http://www.water.com/learn_about%20_water/hs_lrn_art013_p01.asp0)), “20% of Americans are exposed to substandard drinking water. Self Magazine estimates that 50 million Americans-roughly one in five- are exposed to potentially harmful levels of hazardous materials whenever they open a faucet.” Also, “25% of communities provide drinking water that contains excessive levels of biological, chemical or radioactive contaminants.” This leaves many people worried about the water that they are drinking and how safe it exactly is for them selves to be using. In my experiment I wanted to determine how the water that everyone uses to brush their teeth, which was supposedly to clean ones teeth, affects the teeth according to the different hardness’s that they contain.

The author of “Dental Tartar Control” (<http://www.scalefighter.com/magdef.htm>) talks about dental tartar and how build ups on substances on the teeth tear away at the surface of the teeth. Tartar is explained as being "an encrustation on the teeth consisting of salivary secretions, food residue, and various salts (as calcium carbonate or phosphate)." The key ingredient in tartar, the predominant force that encapsulates food, bacteria and saliva into a harden mass on teeth seems to be calcium carbonate. Calcium carbonate is normally insoluble in water, however, the cleaning capacity of acidic water is enough to break down calcium carbonate into calcium bicarbonate which will readily dissolve in water. Calcium carbonate is also the culprit in dental tartar. It is possible that some calcium precipitates directly from hot liquids we drink, particularly if the water has high hardness characteristics.  But, this doesn't explain why some people have few tartar problems while others have a significant recurring tartar build-up. Other possibilities include the effects of bacteria and saliva on the dissolved calcium, and other chemical actions which some people experience and others don't. This suggests that it may not completely be the hardness characteristics of water that are causing these tartar build-ups which are tearing away at the teeth. However, all water has a surface tension which interferes with its ability to clean. The surface tension is further increased when the water has a high mineral content. That is because there are two opposing forces at work at the surface of the water molecule. First is the natural attraction of the surface water molecule to molecules below and to the side, pulling the surface down. Second, is the outward pressure at the surface caused by mineral clusters attempting to leave the water molecule and solidify. However, with the use of brushing teeth with tooth paste, the hardness of water is seen as insignificant in the damaging of the teeth.

There are many types of water researched by SWG INC, ([http://www.water.com/ learn\_about \_water/swg1160\_typofwat.asp](http://www.water.com/%20learn_about%20_water/hs_lrn_art013_p01.asp0)). The differences between these types of water are determined by the source of the water and anything that occurs to the water during processing. The FDA defines bottled water according to the following Standards of Identity. These apply to all bottled water in the U.S. Some of these types include:

|  |  |
| --- | --- |
| **Water Type** | **Characteristics** |
| Artesian Water | * From a well in a confined aquifer * Water level in well must stand at some height above the top of the aquifer * May also be known as "artesian well water" |
| Distilled Water | * Water that has been turned into steam to leave impurities behind * Steam is condensed into pure water * Due to its purity, distilled water is used in the manufacturing of pharmaceutical and liquid dry prescriptions |
| Fluoridated Water | * Contains fluoride that is added within the limitations set by Federal Regulations * Some spring and artesian sources have naturally occurring fluoride in trace amounts |
| Mineral Water | * Must contain no less than 250 parts per million (ppm) total dissolved solids (TDS) with the solids being the minerals in the water * Must come from a geologically and physically protected underground water source * Is distinguished from other types of water by the regular mineral and trace elements present * No minerals may be added to this water |
| Purified Water | * Produced by distillation, deionization, reverse osmosis or other suitable processes that meet the legal definition of "purified water" * May also be known as "demineralized water" |
| Sparkling Water | * Contains, after treatment and possible replacement of carbon dioxide, the same amount of carbon dioxide that it had at emergence from the source * Soda water, seltzer water and tonic water are not considered bottled waters. They are regulated separately and considered softdrinks |
| Spring Water | * Must come from underground formation and flow naturally to the surface of the earth * Emanates from beneath the earth, from under strata that formed in prehistoric times * Must be collected at the spring or through a bore hole tapping the underground formation finding the spring |
| Sterile Water | * Must meet the requirements under "Sterility Tests" in the United States PharMacPPCopoeia * May also be known as "sterilized water." |
| Well Water | * Comes from a hole that is bored, drilled or otherwise constructed in the ground, tapping the water of an aquifer |

All of these different types of water are specifically regulated by the FDA and ensure that there are no harmful contaminations that may be detrimental to the teeth by brushing the teeth with this various types of water.

The EPA, United States Environmental Protection Agency, has also researched both ground water and drinking water (<http://www.epa.gov/safewater/hfacts.html>). They state that drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that water poses a health risk. EPA sets standards for approximately 90 contaminants in drinking water. Here are a variety of water contaminants that are included:

**Microbes**

**Coliform bacteria** are common in the environment and are generally not harmful. However, the presence of these bacteria in drinking water is usually a result of a problem with the treatment system or the pipes which distribute water, and indicates that the water may be contaminated with germs that can cause disease.

**Fecal Coliform and** [**E coli**](http://www.epa.gov/safewater/ecoli.html) are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes can cause short-term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms.

**Turbidity** has no health effects. However, turbidity can interfere with disinfection and provide a medium for microbial growth. Turbidity may indicate the presence of disease causing organisms. These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.

***Cryptosporidium*** is a parasite that enters lakes and rivers through sewage and animal waste. It causes cryptosporidiosis, a mild gastrointestinal disease. However, the disease can be severe or fatal for people with severely weakened immune systems.

***Giardia lamblia*** is a parasite that enters lakes and rivers through sewage and animal waste. It causes gastrointestinal illness (e.g. diarrhea, vomiting, cramps).

**Radionuclides**

**Alpha emitters.** Certain minerals are radioactive and may emit a form of radiation known as alpha radiation. Some people who drink water containing alpha emitters in excess of  EPA's standard over many years may have an increased risk of getting cancer.

**Beta/photon emitters.** Certain minerals are radioactive and may emit forms of radiation known as photons and beta radiation. Some people who drink water containing beta and photon emitters in excess of EPA's standard over many years may have an increased risk of getting cancer.

**Combined Radium 226/228.** Some people who drink water containing radium 226 or 228 in excess of EPA's standard over many years may have an increased risk of getting cancer.

[**Radon**](http://www.epa.gov/safewater/radon.html) gas can dissolve and accumulate in underground water sources, such as wells, and in the air in your home. Breathing radon can cause lung cancer. Drinking water containing radon presents a risk of developing cancer. Radon in air is more dangerous than radon in water.

**Inorganic Contaminants**

[**Arsenic**](http://www.epa.gov/safewater/arsenic.html)**.** Some people who drink water containing arsenic in excess of EPA's standard over many years could experience skin damage or problems with their circulatory system, and may have an increased risk of getting cancer.

**Fluoride.** Many communities add fluoride to their drinking water to promote dental health. Each community makes its own decision about whether or not to add fluoride. EPA has set an enforceable drinking water standard for fluoride of 4 mg/L (some people who drink water containing fluoride in excess of this level over many years could get bone disease, including pain and tenderness of the bones). EPA has also set a secondary fluoride standard of 2 mg/L to protect against dental fluorosis. Dental fluorosis, in its moderate or severe forms, may result in a brown staining and/or pitting of the permanent teeth. This problem occurs only in developing teeth, before they erupt from the gums. Children under nine should not drink water that has more than 2 mg/L of fluoride.

[**Lead**](http://www.epa.gov/safewater/dwh/c-ioc/lead.html) typically leaches into water from plumbing in older buildings. Lead pipes and plumbing fittings have been banned since August 1998. Children and pregnant women are most susceptible to lead health risks.

This data demonstrates that although there are many health risks due to the different contaminants, all but one contain not health risk to brushing one’s teeth with different water. Dental fluorosis, the one exception, only results in harming the teeth when more than 2mg/L is used by children who still contain developing teeth. Therefore, overall the contaminants found in water do not affect the teeth.

However, many water suppliers add a disinfectant to drinking water to kill germs such as giardia and e coli. Especially after heavy rainstorms, your water system may add more disinfectant to guarantee that these germs are killed.  There are also disinfection byproducts, which form when disinfectants added to drinking water to kill germs react with naturally-occuring organic matter in water. These disinfectants and disinfection byproducts include:

**Disinfectants**

**Chlorine.** Some people who use drinking water containing chlorine well in excess of EPA's standard could experience irritating effects to their eyes and nose.  Some people who drink water containing chlorine well in excess of EPA's standard could experience stomach discomfort.

**Chloramine.** Some people who use drinking water containing chloramines well in excess of EPA's standard could experience irritating effects to their eyes and nose.  Some people who drink water containing chloramines well in excess of EPA's standard could experience stomach discomfort or anemia.

**Chlorine Dioxide.** Some infants and young children who drink water containing chlorine dioxide in excess of EPA's standard could experience nervous system effects.  Similar effects may occur in fetuses of pregnant women who drink water containing chlorine dioxide in excess of EPA's standard.  Some people may experience anemia.

**Disinfection Byproducts**

**Total Trihalomethanes.** Some people who drink water containing trihalomethanes in excess of EPA's standard over many years may experience problems with their liver, kidneys, or central nervous systems, and may have an increased risk of getting cancer.

**Haloacetic Acids.** Some people who drink water containing haloacetic acids in excess of EPA's standard over many years may have an increased risk of getting cancer.

**Bromate.** Some people who drink water containing bromate in excess of EPA's standard over many years may have an increased risk of getting cancer.

**Chlorite.** Some infants and young children who drink water containing chlorite in excess of EPA's standard could experience nervous system effects.  Similar effects may occur in fetuses of pregnant women who drink water containing chlorite in excess of EPA's standard.  Some people may experience anemia.

Like the water contaminants, none of the hazards described, due to the disinfectants and the disinfection byproducts, effect the health of the teeth when subjected to the different types of water. This suggests that when brushing teeth with the different hardness’s of water, there shouldn’t be any effect on the teeth.

Other extensive research done on fluoride helps to enlighten the necessity of fluoride, showing that it is only a risk to people’s teeth who use water that does not contain minimal amounts of fluoride. In a news article, “Children’s Teeth May Suffer from Bottled Water Boom” ([http://www.junkscience.com/nov98/teeth.htm](http://www.junkscience.com/nov98/teeth.html)), Erica Noonan states that consumption of fluoride in tap strengthens the developing teeth of children. Fluoride is the mineral dentists say helps develop stronger teeth in children and helps prevent tooth decay in adults. On a daily basis, fluoride is taken in through water or foods, processed by the body and re-secreted in saliva where it aids in remineralizing teeth under attack from acid-producing bacteria. Therefore, fluoride helps prevent the teeth from being damaged by water contamination. In “Toxic Chemicals In Your Water” (<http://www.holisticmed.com/fluoride/>), it states that fluoride compounds which are put in water (fluoridation), toothpaste and supplement tablets (including some vitamins) were never tested for safety before approval. However, the many detriments of fluoride do not effect the health of teeth. However, the effects do include: neurotoxic and lowers IQ, causes cancer, changes bone structure and strength, causes birth defects and perinatal deaths, impairs immune system, causes acute adverse reactions, causes initial stages of skeleton fluorosis, increases lead and arsenic exposure, contributes to the development of repetitive stress injury, and causes a large number of acute poisonings. In “Bottled Water Bad for Teeth” (<http://www.nzherald.co.nz/storyprint.cfm?storyID=156573>), by Francesca Mold, a health reporter, it states that the health fad for drinking filtered and bottled water is raising dentists' concerns that a generation of young people are doing serious damage to their teeth. Also, constant sipping of sport drinks is causing an "acid attack" on the teeth of the young. Bottled water contains a maximum of just 0.1 part of fluoride per million. The dentists say the lack of fluoride is causing a rise in cavities among young, otherwise healthy people. Dr McKegg said there appeared to be an increase in the number of children with tooth decay from homes with water filters. Also, an Auckland Healthcare specialist paediatric dentist, Callum Durward, said "sipper" bottles, containing highly acidic fruit or sport drinks, were also harmful and severely eroded tooth enamel. Therefore, it is not the fluoride in the water that is causing destruction to the tooth’s enamel, but is the bottled drinks that are deprived of fluoride.

One other interesting about the killing of germs and preventing damage to teeth is seen in “Oxygen Water” (<http://www.hiosilver.com/information.htm>). Oxygen inhibits the bad (anaerobic) bacteria in your mouth.  Anaerobic bacteria in your mouth are responsible for bad breath, tooth decay, and gum disease. Therefore the use of oxygen also helps prevent tooth damage.

Through the various works of literature encountered, we have seen both what the different types of water are and what they consist of. With the exception of an overdose in fluoride, the research shows that even though the contaminants in water may affect people’s health, the contaminants do not affect the enamel of people’s teeth. This indicates that the use of different hardness’s of waters used to brush people’s teeth across the nation does not have an impact on destroying the enamel of people’s teeth.

**Procedures**

1. Acquire the following materials:

* 6 Human Teeth
* 3 Toothbrushes
* Toothpaste
* 9 Glass Beakers
* Incubator large enough to fit 6 plastic cups
* 180ml of bicarbonate
* 6 liters of Distilled Water
* 1 liter of Bottled Water
* 1 liter of Water with a high concentration of contaminations (Pleasanton water)
* pH Tester

2. Create Solution of Saliva

* To prepare a 30 molar solution of bicarbonate, I filled up a beaker with 30ml of bicarbonate. Then I filled the rest of the beaker with distilled water until the total volume reached 1 liter.
* Use 30mMol/L solution because it’s the concentration when there is an intermediate flow of bicarbonate in the saliva.
* Take pH tester and adjust it till you reach 7.46 pH
* *See Statistical Analysis (In Appendices)*
* Do this for 6 beakers

3. Place one tooth in the solution in each of the 6 glass beakers.

4. Set up water station, with 3 beakers; 1 filled with Distilled Water, 1 filled with Bottled Water, and 1 filled with Water with a high concentration of contaminations (Pleasanton water). Put the three toothbrushes and toothpaste at this station.

5. Put the 6 beakers with the teeth in them in the incubator at 98 F

6. Three times daily take the teeth out and brush them with tooth paste and their designated water (2 teeth are designated for each type of water).

7. Collect results for 3 weeks

**Findings**

Through out the duration of the experiment, the teeth’s enamel remained undamaged. These results help to confirm the research that was gathered. Even though there are extremely hazardous substances that classified as contaminants in water, they fail to cause damage to the teeth. Also, with the little amount of water used when brushing one’s teeth, not enough contaminants are present to even reach beginning stages of damaging the teeth’s other walls. Therefore, the contaminants found in water do not effect the enamel of the teeth when using contaminated water to brush one’s teeth.

**Conclusions**

At the end of the three weeks there were no changes in the appearances in any of the teeth. There didn’t seem to be a build up of contaminants on the teeth and the teeth didn’t seem to be damaged in any way.

This is most likely due to the contaminants in the water. It was discovered through research that there are many contaminants in water, however none of them affect the teeth. Also, the build ups of Calcium carbonate didn’t have long enough to settle on the teeth, due to the constant brushing, to have time to create damage to the teeth. The use of saliva also helped to continually remineralize teeth under attack from acid-producing bacteria. Due to the constant brushing and short time period of the experiment, my results prove my hypothesis wrong. The different concentrations of contaminants did not affect the enamel/surface area of the teeth when used in the process of brushing ones teeth.

**Significance/Recommendations  
   
People can use my research in a variety of ways. From my experiment and research I have proven that different water contaminations do not affect the enamel of the teeth. Now people do not have to go out of their way to pay millions of dollars to use other water for brushing their teeth. However, as seen in my research these water contaminants are possible of many other hazards such as cancer and nausea. This information should be used by the water company in determining the hazards of water and eliminating these contaminants. This information will also suggest to people that minimal amounts of water with many contaminants should be used in cooking and other actions that involve consumption of the contaminants. This information informs the public about the risks that are present due to the various contaminants and helps them to be more aware of what they are consuming.  
  
Also, my research shows that although fluoride may be seen as being hazardous, it may only damage the teeth if used in excess. It also informs the public that have children under the age of nine, whose teeth are still forming, that they should especially use minimal amounts of fluoride. However, the complete abolishment of fluoride will be detrimental to ones teeth because it helps fight bacteria and makes teeth stronger. This informs people that they should not only drink bottled water because it does not contain fluoride.   
  
This research and experimentation will not only help people to be more informed about what is going on, but will make them more aware of what they are consuming. People will be able to make wiser and healthier decisions about what they intake and what types of water they use. My research can not only be used for knowledge about how water effects the teeth, but also how if effects the entire human body.  
  
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Saliva Solution  
  
Using the Henderson-Hasselbach Equation I calculated the pH of a 30 molar solution of bicarbonate. I used the 30mMol/L solution because it’s the concentration when there is an intermediate flow of bicarbonate in the saliva.  
  
   
  
  
  
  
  
  
  
  
  
  
In this equation, pK = 6.1. The concentration of the carbonic acid is remarkably constant at 1.3mMol/L. We are using a 30mMol/L concentration for the bicarbonate.  
  
 pH = 6.1 + log (30/1.3)  
 pH ( 6.1 + 1.363  
 pH ( 7.463  
  
Mass = Moles/Molar Mass  
Moles = 30mol;  
Molar Mass = 1 + 12 + [3 x 16] = 61g/mol  
Mass = [30mol]/[61g/mol]  
Mass ( .49g  
  
To prepare a 30mMol/L solution of bicarbonate, I took .49g of bicarbonate in a beaker. I filled up rest of the beaker with water until the total volume [water + bicarbonate] reached 1 liter.  
  
Daily Log  
Wednesday, Dec. 5, 2002  
Researched water contamination  
  
Saturday, Dec 8, 2002  
Researched water contamination  
  
Thursday, Dec 13. 2002  
Researched water contamination  
  
Saturday, Dec 15, 2002  
Researched water contamination  
  
Sunday, Dec 16, 2002  
Researched water contamination  
  
Monday, Dec. 17, 2002  
Took pictures of teeth  
  
Tuesday, Dec.18, 2002  
Took pictures of teeth  
  
Tuesday, Jan. 15, 2002  
Researched water contamination  
  
Saturday, Jan. 26, 2002  
Researched water contamination  
  
Sunday, Jan 27, 2002  
Researched water contamination  
  
Sunday, Feb.12, 2002  
Set up the incubator and made saliva solutions. Set up experiment and turn incubator on before I went to sleep.  
  
Monday, Feb. 11, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Tuesday, Feb. 12, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Wednesday, Feb. 13, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Thursday, Feb. 14, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Friday, Feb. 15, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Saturday, Feb. 16, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Sunday, Feb. 17, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
~Haven’t noticed any change in the teeth’s enamel  
  
Monday, Feb. 18, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Tuesday, Feb. 19, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Wednesday, Feb. 20, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Thursday, Feb. 21, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Friday, Feb. 22, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Saturday, Feb. 23, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Sunday, Feb. 24, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
~Haven’t noticed any change in the teeth’s enamel  
  
Monday, Feb. 25, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Tuesday, Feb. 26, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Wednesday, Feb. 27, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Thursday, Feb. 28, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
  
Friday, March 1, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Saturday, March 2, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
  
Sunday, March 3, 2002  
I brushed the teeth at 6am, 3pm, and 10pm   
At 10 pm I turned off the incubator  
After examining the teeth I noticed no damage to the enamel.**