



**CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY**

Name(s) Jay Kamat; Alex Nagase	Project Number S1808
Project Title Exploring the Effect of Water Hardness on the Mpemba Effect	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals This experiment was designed to test whether water hardness would enhance the Mpemba Effect, a phenomenon where hot water freezes faster than cold water. Hypothetically, cold water would freeze before hot water due to Newton's Law of Cooling because it begins at a lower temperature. It is hypothesized that harder water would decrease the amount of time between the freezing times of hot and cold water samples of equal hardness. In other words, the hypothesis predicts that the Mpemba effect would be more evident in harder samples of water.</p> <p>Methods/Materials The hypothesis was tested by preparing test tubes with 10 ml water samples of 3 different hardnesses, 1 ppm, 200 ppm, and 400 ppm. One sample of each hardness was heated to 50°C. A second set of samples was heated to 35°C. All 6 test tubes were placed in a freezer and the temperature was monitored using a data collection device with stainless steel temperature probes. By analyzing the graphs of temperature vs. time, the freezing point of each pair of samples was determined.</p> <p>Results Once a list of freezing times was compiled, the difference in the freezing time between that of the hot and cold samples of each hardness was calculated. The freezing time for the hot sample (in minutes after freezing started) was subtracted from the time it took for the cold sample to freeze. If the temperature difference was negative, the presence of the Mpemba effect was confirmed. The graphs consistently showed that the harder samples tended to have a lower difference in freezing time between hot and cold samples. In some cases, the harder samples of water showed the Mpemba effect while their softer counterparts did not. There was a direct correlation between water hardness and the difference in time that it took the hot and cold samples to freeze.</p> <p>Conclusions/Discussion Through the data obtained in the experiment, it can be concluded that water hardness had an effect on the difference in freezing times of hot and cold water. The harder water produced a smaller time difference between the freezing times of hot and cold samples, while the softer water resulted in a larger time difference. However, further testing with a more optimal control over freezing conditions will be required to decide whether water hardness directly or indirectly causes the Mpemba Effect to occur.</p>	
Summary Statement This projects examined whether water hardness was a contributing factor of the Mpemba Effect.	
Help Received Dr. Plano (Teacher) allowed us to use the high school laboratory equipment and a refrigerator and supervised us; Other science and math teachers in school helped to peer review our project	