

**Atomic Absorption Spectroscopy: Tap Water Analysis**

Corri L. Alexander

Chemistry 31: Quantitative Analysis

Lab Section 5

Sacramento State University

November 13, 2008

Prepared under the direction of Dr. Dixon, Dr. Toofan, and Dr. Baker.

## Contents

1. Abstract.....	3
2. Introduction.....	3
3. Objectives.....	4
4. Materials and Methods.....	5
5. Results and Discussion.....	6
6. Conclusions and Recommendations.....	8
7. References.....	8

## **Abstract**

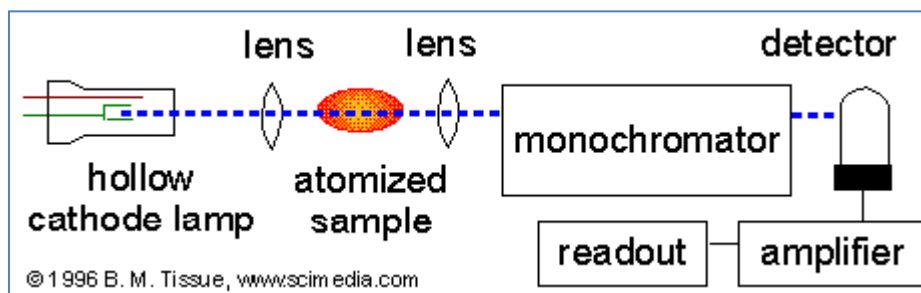
Water quality is highly dependent on the concentrations of both magnesium and calcium. The concentrations of these ions can be deduced accurately in a water sample through analysis by atomic absorption spectroscopy. This study focuses on a sample from Orangevale California. The data shows the calcium concentration to be  $5.7 \pm 0.1$  ppm, and the magnesium concentration to be  $1.9 \pm 1.1$  ppm. This results in the conclusion that the water sample from this region is not hard.

## **Introduction**

Residential water quality is a matter of importance to both residents and water providers. One aspect of water quality is known as water hardness, consumers would recognize hard water as the cause of common soap scum irritation- resulting in clogged pipes and even decreased life of toilet flushing units (Wikipedia). Hard water is generally caused by high concentrations of calcium and magnesium ions. Drinking water comes from either surface water (lakes, rivers and streams) or ground water sources (via wells), and this natural environment allows these ions into the water source (U.S E.P.A). Calcium enters the water as either calcium carbonate from limestone, or as calcium sulfate from other mineral deposits, while the predominant source of magnesium is dolomite (Wikipedia).

Knowing that hard water can cause complications- it's nice to know how hard a sample of water really is. It is useful to realize that for a specific region, magnesium and calcium concentrations tend to be very similar, as the water is from the same sources. In this study a tap water sample was taken from Orangevale California (Lat  $38^{\circ}40'4.38''$  N and Long  $121^{\circ}12'25.87''$  W) and analyzed for water hardness. According the San Juan Water District, the Orangevale water source is American River watershed and according the San Juan Water District 2007 consumer report, the cause of most calcium and magnesium in the water was natural mineral deposits.

The water samples (including that whose data is reported here) are analyzed through atomic absorption spectroscopy (see figure 1). The instrument measures the absorption of light at specific



**Figure 1:** Atomic absorption spectrometer diagram

wavelengths by elements in the free state, such as calcium and magnesium. Understanding that a plot of absorbance versus concentration (otherwise known by Beer's Law) produces a linear relationship within a specific range of concentrations is the key to this method. Measuring the absorbance of standard solutions and plotting them against their respective known concentrations will produce a calibration curve that will be extremely linear (B. Baker, 39-41). Comparison of absorbance data from the unknown tap sample will allow the determination of its calcium and magnesium concentration.

## Objectives

One major objective of this project was to determine the calcium and magnesium concentrations in a specific region as a part of the tap water study being conducted by the chem 31 faculty. The other major objective is for the students participating in the study to better understand the Beer's Law relationship as well as experience and understand the theory behind the atomic absorption spectrometer.

## Materials and Methods

### I. Preparation of Standard Solutions and Calibration Curves

From a stock solution of 601.2 ppm calcium, four different concentration standards were prepared within the range of linearity (1-10ppm) with a minimum volume of 250 ml. Using the Atomic Absorbance Spectrometer (AAS- see figure 1), the absorbance was measured for each calcium standard using the calcium cathode lamp. The absorbance was plotted against the concentrations in excel, thus confirming the linear relationship, and this graph became the calibration curve for calcium. The same process was repeated to create a calibration curve for stock 10,000 ppm magnesium, the only differences being the range of linearity (0.1-1ppm) and the use of a magnesium cathode lamp.

### II. Dilution of unknown tap sample

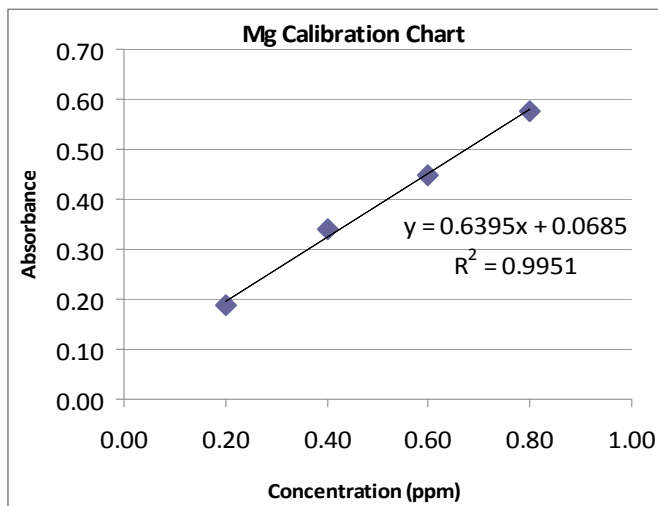
Based on previous tap water analysis results for the region, the magnesium concentration was estimated to 2.61ppm and the calcium concentration was estimated to 5.08ppm. These estimates allowed for a rough estimate of the dilution that would need to occur to allow the tap water concentration and resulting absorbance to fall within the range of both calibration curves. Based on this approximation, one sample was left undiluted to be measured with the calcium cathode lamp (approximately 5.08 ppm), and another sample was diluted with a 3:100 ratio (to approximately 0.784ppm) to be used with the magnesium cathode lamp (see chart III). An atomic absorption analysis was performed on both samples, and the resulting absorption values were compared using the calibration charts from part I.

**Tap water Dilution (chart III)**

Ion	geographical app. concentration	dilution factor	final concentration
Magnesium	2.61	3 ml: 100ml	0.784 ppm
Calcium	5.08	1ml : 1 ml	5.08 ppm

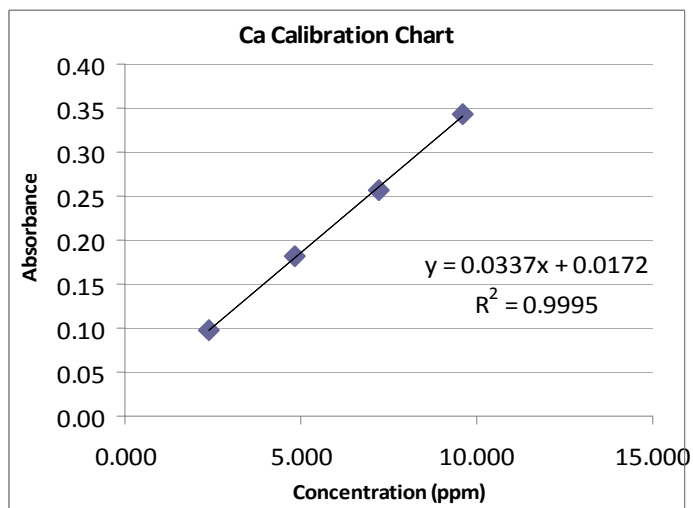
## Results and Discussion

The calibration curve for magnesium had an  $R^2$  value of 0.9951, showing a successfully linear plot of concentration vs. absorbance (Chart I). The calibration curve for calcium had an  $R^2$  value of



**Chart I:** Calibration Curve for Magnesium standards.

0.9995, and is therefore also a good representation of the linearity of a Beer's Law plot (Chart II).



**Chart II:** Calibration Curve for Calcium standards

The tap water analysis led to the determination of the calcium and magnesium concentrations in the tap water sample. The concentration of calcium in the original tap water sample was calculated to be 5.7 ppm, and the magnesium concentration was 1.9 ppm (Chart IV). This is a reasonable value in comparison to the tabulated geographical approximation of the concentrations of magnesium (2.69 ppm) and calcium (5.08 ppm) in the area.

<b>Diluted Tap water Absorbance (Mg)</b>	
0.105	measured y number of replicates K
1	
<b>Diluted Conc.</b>	<b>Solution</b>
0.057	derived x (ppm)
0.033	standard dev. (x)
<b>Original Conc.</b>	<b>Solution</b>
0.03	dilution factor original concentration
1.9	
1.1	standard deviation

<b>Diluted Tap water Absorbance (Ca)</b>	
0.208	measured y number of replicates K
1	
<b>Diluted Solution Conc.</b>	
5.661	derived x (ppm)
0.093	standard dev. (x)
<b>Original Solution Conc.</b>	
1	dilution factor
5.7	original concentration
0.1	standard deviation

**Data Chart IV:** Concentration determination and standard deviation of Ca and Mg

One source of error in this study is that while measuring the absorbance of the tap water sample for magnesium content, the absorbance was .105. This is outside of the range of the original magnesium calibration curve (chart I), which ranged from 0.187 to 0.578. This reduces the reliability of the data because there is not a proven linearity at this absorbance. Another source of error in this lab is in the multiple dilutions. For example, the stock magnesium standards were diluted twice to get to the final concentration used in the experiment. With every water transfer there are more chances for error.

## Conclusions and Recommendations

In conclusion, the water sample obtained from Orangevale Ca, was determined to be soft water. The concentrations of calcium and magnesium were relatively low in comparison to other areas of the region. They were comparable to the geographical approximations made at the beginning of the study. A recommendation for anyone repeating this lab is to perform more standardizations with a wider range of concentrations to ensure that all data points will fall within a verified linear range. Also I would recommend that a researcher be extremely careful with all dilutions so as to have very precise calculations.

## References

B. Baker, R. Dixon. (2008) *Chemistry 31: Inorganic Quantitative Analysis Laboratory Manual*. Sacramento State University.

B. Baker, Tap Water Study. (unknown publication date) [Regional Map of Ca<sup>2+</sup> data, Regional Map of Mg<sup>2+</sup> data.] Retrieved November 22, 2008 from <http://www.csus.edu/indiv/b/bakerb/Chem31/Tapwater.htm>

San Juan Water District (2007). *2007 Consumer Confidence Report*. Retrieved November 22, 2008, from <http://www.sjwd.org/pdfs/SJWD2007CCR.pdf>

San Juan Water District (2007). *Water Distribution*. Retrieved November 22, 2008, from <http://sjwd.org/WaterDist.htm>

Tissue, Brian M., Science Hypermedia (August 21, 1996) *Atomic-Absorption Spectroscopy* (AA). Retrieved November 22, 2008, from <http://elchem.kaist.ac.kr/vt/chem-ed/spec/atomic/aa.htm>

U.S EPA (November 14, 2008). *Geography of Water*. Retrieved November 22, 2008 from <http://www.epa.gov/waters/about/geography.html>

Wikipedia, The Free Encyclopedia (2008, November 26). *Hard Water*. Retrieved November 22, 2008, from [http://en.wikipedia.org/w/index.php?title=Hard\\_water&oldid=254262919](http://en.wikipedia.org/w/index.php?title=Hard_water&oldid=254262919)