Untitled Essay, Research Paper

The Chemistry of Natural Water INTRODUCTION The purpose of this experiment is to explore the hardness of the water on campus. Hard water has been a problem for hundreds of years. One of the earliest references to the hardness or softness of water is in Hippocrates discourse on water quality in Fifth century B.C. Hard water causes many problems in both in the household and in the industrial world. One of the largest problems with hard water is that it tends to leave a residue when it evaporates. Aside from being aesthetically unpleasing to look at, the build up of hard water residue can result in the clogging of valves, drains and piping. This build up is merely the accumulation of the minerals dissolved in natural water and is commonly called scale. Other than clogging plumbing, the build up of scale poses a large problem in the industrial world. Many things that are heated are often cooled by water running thru piping. The build up of scale in these pipes can greatly reduce the amount of heat the cooling unit can draw away from the source it is trying to heat. This poses a potentially dangerous situation. The build up of excess heat can do a lot of damage; boilers can explode, containers can melt etc. On the flip side of the coin, a build up of scale on an object being heated, a kettle for example, can greatly reduce the heat efficiency of the kettle. Because of this, it takes much more energy to heat the kettle to the necessary temperature. In the industrial world, this could amount to large sums of money being thrown into wasted heat. In addition to clogging plumbing and reducing heating efficiency, the build up of hard water also adversely affects the efficiency of many soaps and cleansers. The reason for this is because hard water contains many divalent or sometimes even polyvalent ions. These ions react with the soap and although they do not form precipitates, they prevent the soap from doing it’s job. When the polyvalent ions react with the soap, they form an insoluble soap scum. This is once again quite unpleasing to look at and stains many surfaces. The sole reason for all these problems arising from hard water is because hard water tends to have higher than normal concentrations of these minerals, and hence it leaves a considerable amount more residue than normal water. The concentration of these minerals is what is known as the water’s Total Dissolved Solids or TDS for short. This is merely a way of expressing how many particles are dissolved in water. The TDS vary from waters of different sources, however they are present in at least some quantity in all water, unless it has been passed through a special distillation filter. The relative TDS is easily measured by placing two drops of water, one distilled and one experimental on a hotplate and evaporating the two drops. You will notice that the experimental drop will leave a white residue. This can be compared to samples from other sources, and can be used as a crude way of measuring the relative TDS of water from a specific area. The more residue that is left behind, the more dissolved solids were present in that particular sample of water. The residue that is left, is in fact, the solids that were in the water. Another, perhaps more quantitative way of determining hardness of water is by calculating the actual concentrations of divalent ions held in solution. This can be done one of two ways. One is by serially titrating the water with increasing concentrations of indicator for Mg++ and Ca++ (we will be using EDTA). This will tell us the approximate concentration of all divalent ions. This method of serial titrations is accurate to within 10 parts per million (ppm) . Another possible method for determining the hardness of water is by using Atomic Absorption Spectrophotometry or AA for short. AA is a method of determining the concentrations of individual metallic ions dissolved in the water. This is accomplished by sending small amounts of energy thru the water sample. This causes the electrons to assume excited states. When the electrons drop back to their ground states, they release a photon of energy. This photon is measured by a machine and matched up to the corresponding element with the same E as was released. This is in turn is related to the intensity of the light emitted and the amount of light absorbed and based on these calculations, a concentration value is assigned. A quick overview of how the atomic absorption spectrophotometer works follows. First, the water sample is sucked up. Then the water sample is atomized into a fine aerosol mist. This is in turn sprayed into an extremely high intensity flame of 2300 C which is attained by burning a precise mix of air and acetylene. This mixture burns hot enough to atomize everything in the solution, solvent and solute alike. A light is emitted from a hollow cathode lamp. The light is then absorbed by the atoms and an absorption spectrum is obtained. This is matched with cataloged known values to attain a reading on concentration. Because there are so many problems with hard water, we decided that perhaps the water on Penn State’s campus should be examined. My partners and I decided to test levels of divalent ions (specifically Mg++ and Ca++ ) in successive floors of dormitories. We hypothesized that the upper level dormitories would have lower concentrations of these divalent ions because seeing as how they are both heavy metals, they would tend to settle out of solution. The Ca++ should settle out first seeing how it is heavier than the Mg++, but they will both decrease in concentration as they climb to higher floors in the dormitories. PROCEDURE We collected samples from around Hamilton Halls, West halls. In order to be systematic, we collected samples in the morning from the water fountains near the south end of the halls. We collected water samples from each floor in order for comparison. The reason we collected them in the morning was so that the Mg++ and Ca++ would be in noticeable quantities. We then went about and tested and analyzed via serial titrations and via Atomic Absorption Spectrophotometry. We also obtained a TDS sample merely for the sake of comparison, and to ensure that were in fact dissolved solids in our water samples (without which this lab would become moot). For the serial titration, we merely mixed the water sample with EBT, and then with increasing concentrations of EDTA. The EBT served as an indicator to tell us when the concentrations of the EDTA and the divalent ions in solution were equal (actually it told us when Mg++ was taken out of solution but that served the same purpose). This allowed us to find the concentration of the divalent ions dissolved in solution. Based on this, we calculated the parts per million and the grains per gallon for each water sample. Finally, we took an AA reading for each sample. This gave us absorption values and concentration values for each of the two main metals we were observing; Ca++ and Mg++. We then plotted a graph of Atomic Absorption Standards. These were values given to us by the AA operator. These values helped us to calibrate the machine. The parts per million that we find will be based on plugging in the reported absorption value into the resulting curve from the graph of these values. The resulting concentration was used as the final value for the hardness for that particular sample. All calculations and conclusions were done based on these final values obtained for the concentration of Ca++ and Mg++. For more detail, refer to full in depth procedure as directed by: Penn State Version of… Chemtrek August 1996 – July 1997; Stephen Thompson; Prentice Hall; Englewood Cliffs, NJ 07632; ? 199 RESULTS Molarity x (100g CaCO3 / 1 mole CaCO3 ) x (1000 mg / 1g) = Xmg/1000g = ppm Grains/Gallon = ppm /17.1 Example: (1.6 x 10 -3 moles / 1 Liter) x (100g CaCO3 / 1 mole CaCO3 ) x (1000 mg / 1g) = 160 ppm 160 ppm/17.1 = 9.35 grains/gallon Serial Titration Results Name: # Molarity Parts Per Million Grains Per Gallon Samir Sandesara 1 1.6 x 10 -3 160 9.35 Andy 2 1.6 x 10 -3 160 9.35 Ben 3 1.2 x 10 -3 120 7.01 Tom 4 1.8 x 10 -3 180 10.5 Table #1: This table displays the values obtained by serial EDTA titration of the water samples. Conversion Factors Given by AA operator: Ca++ = 2.5 Mg++ = 4.2 Ca++ x 2.5 = CaCO3 hardness ppm value Mg++ x 100 x 4.5 = Mg CO3 hardness ppm value \*NOTE: the Mg++ is x 100 because it was diluted before it was put into the AA. Example: Ca++: 27.52 x 2.5 = 68.8 ppm 4.02 g/gal Mg++: .251 x 100 x 4.2 = 105.42 6.16 g/gal Atomic Absorption Values Name : # Abs Mg++ Abs Ca++ AA ppm Mg++ AA ppm Ca++ ppm Mg++ ppm Ca++ g/Gal Mg++ g/Gal Ca++ Samir 1 0.2270 0.5923 0.251 27.52 105.42 68.8 6.16 4.02 Andy 2 0.2041 0.5493 0.225 25.10 92.40 62.75 5.40 3.67 Ben 3 0.3633 0.5800 0.401 26.83 168.22 67.07 9.88 3.90 Tom 4 0.2673 0.5589 0.295 25.65 123.90 64.11 7.24 3.75 Table #2: This table displays the values obtained from AA analyzation, and shows the hardness of the water as contributed by each individual element. Absorbency Values Parts Per Million 0.000 0.0 0.125 0.1 0.403 0.5 0.716 1.0 Absorbency Values Parts Per Million 0.0000 0.000 0.0142 0.493 0.0262 0.985 0.0536 1.970 0.2360 9.850 0.4540 19.700 0.9230 49.250 Floor Number Hardness (ppm) 1 174.3 2 159.1 3 235.5 4 188.0 DISCUSSION The final hardness values were obtained by graphing the AA Standards on the previous page and then plugging in the absorption values give by the AA (Table #2). This is the grey line that appears in both graphs. When this line was extended down from the point of intersection, it was able to read the ppm value at that point. The ppm value for both Ca++ and the Mg++ were then summed to attain the final hardness of the water. The other numbers above reveal much about the water in Hamilton Hall. Looking at the final hardness values that were attained, it is clear that the two upper floors had harder water than the lower floors. However, table #2 shows that the concentration of Ca++ decreased overall as the water climbed higher in the dormitory. What was unexpected was that the concentration of Mg++ actually increased as it climbed higher. As of present, I have no rational scientific explanation for this. The only possible explanation I could possibly think of is perhaps there is something within the plumbing that contains Mg and the further the water travels in it, the more dissolves of the Mg dissolves. Aside from that, there does not seem to be any possible explanation. What is also interesting is that with the exception of the #3 sample, the hardness values attained from the AA were very similar to those attained by serial EDTA titration. These indicates a low source of error and gives support to my numbers. Even more support is added to the numbers when the ppm values are added up in Table 2. These values, for the most part, also seem to be in a relatively tight “ball park” of the final AA values. Given that the accuracy of serial titrations is ? 10 ppm, it is extremely safe to say that my numbers are correct. A brief overview of the numbers seems to show that there is indeed a trend, and the more in-depth look at the numbers shows that they all seem to back each other up. This seems to imply a that most if not all of the results are quite accurate and precise. CONCLUSION Upon completion of this lab, it can be said that the data supports only half of the original hypothesis. Yes, the Ca++ did seem to decrease as the water got further from the source and climbed higher in the dormitories. However, the Mg++ did not. Instead it did quite the opposite and showed a general trend of increasing in concentration as it got further away from the source and higher in the dormitories. Perhaps a viable explanation could be attained if studies were done on the plumbing inside the building. Perhaps there is a high concentration of magnesium in the solder used to hold the pipes together. Perhaps it is not in the pipes but rather perhaps the people on the upper floors get up later and therefore at the time of collection, the water in the upper floors had been sitting longer than that on the lower floors. In either case,. More investigation would have to be conducted in order determine what caused the unexpected results. In light of this discrepancy, the overall accuracy of the lab was very good. The numbers all seem to back each other up and correlate very well. As was mentioned in the previous section, the precision and accuracy with which this lab was carried out seems to indicate that there is very little source of error. The only one that was possibly flawed was sample #3. This could have been due to an error in the dilution or any other factor. Since I personally did not carry out that portion of the experiment, I cannot be sure. However, the other 3 samples provide more than ample ammounts of accurate information. Overall, it seems that the lab was quite well done. The hypothesis would have to be revised and as of this point, without further investigation, it would have to be reformulated to say that only the Ca++ would decrease in concentration whereas the Mg++ would increase. REFERENCES 1) Brown, Theodore L. et al; Chemistry The central Science; Sixth Edition; Prentice Hall, Englewood Cliffs, NJ; ?1994 2) Stephen Thompson; Penn State Version of…Chemtrek; August 1996 – July 1997; Prentice Hall; Englewood Cliffs, NJ; ? 1990 3) Internet Resource; http://www.kinetico.com/hard.htm