

Relationship between Hardness Levels in Eslava Creek and Rainfall Amounts in Mobile, AL

T.R. Risner, Department of Earth Sciences, University of South Alabama, Mobile, AL 36688.
E-MAIL: wxman08@yahoo.com.

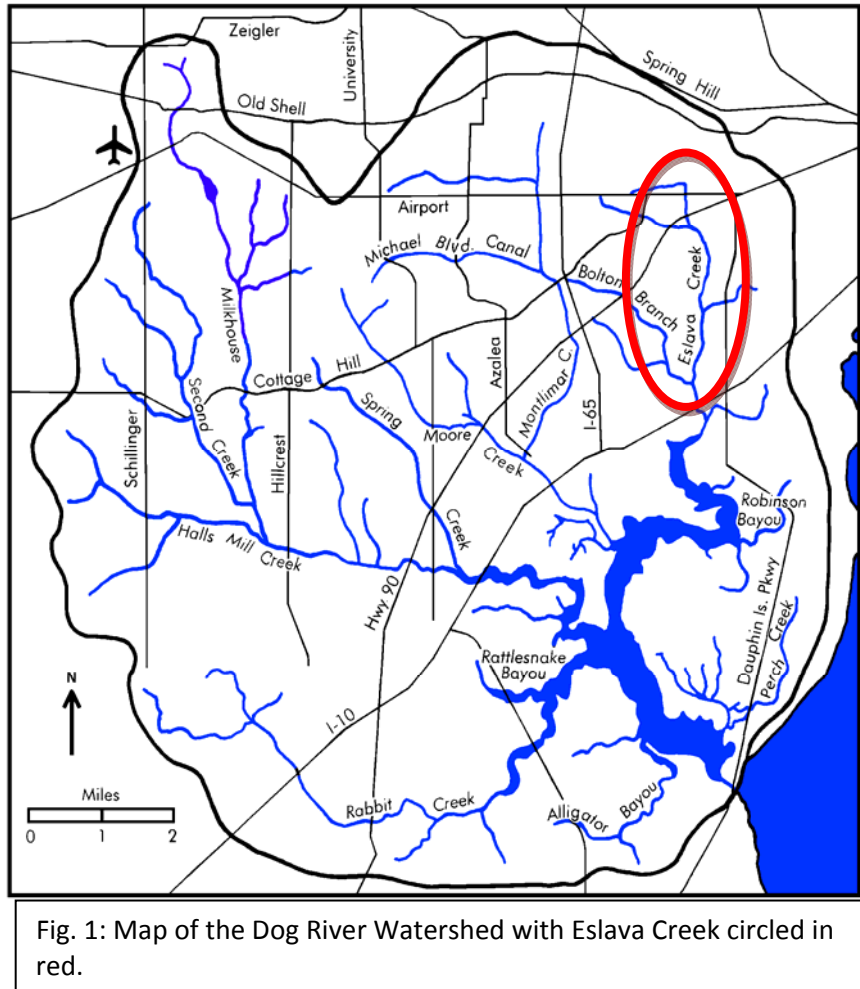
Hard water can adversely affect humans in different ways including interfering with household cleaning, breaking of appliances, and clogging of water pipes. Water hardness in Eslava Creek is affected in several different ways. Abnormal precipitation amounts in the Mobile, Alabama area is one of the major effects on water hardness in the creek. Increased rainfall amounts in the city of Mobile cause an increase in the rate of flow of Eslava Creek which does not allow dissolved metals in the creek to settle, therefore decreasing hardness levels. Although, if levels of rainfall are excessively high, like in cases where the area floods, hardness levels momentarily increase due to weathering and surface run-off. On the contrary, if rainfall amounts are abnormally low for the city of Mobile, flow rates in Eslava Creek slow and allow dissolved metals to remain in the creek instead of flowing downstream, which will increase hardness levels. I show this indirect relationship by comparing monthly National Weather Service rainfall amounts to hardness levels in Eslava Creek from the Alabama Water Watch organization, starting in January 1999 and ending in August 2007. The comparison shows as rainfall amounts trend towards lower levels, hardness levels actually increase, while decreasing when rainfall amounts trend towards higher levels.

Keyword: Water Hardness, Precipitation, Flow Rates

Introduction

Water hardness is an aspect of water quality in streams all over the world. Hard water can lead to appliance failures, clogging of pipes, and problems with household cleaning. Water hardness is also important to the culture of fish that are found in the stream (Wurts 2007). Stream water hardness is the concentration of cations; specifically calcium, magnesium, iron, manganese, and salt in water (Wheelin Jesuit University 2004). This study took place in Eslava Creek, which is located in Mobile, Alabama and is part of the Dog River Watershed. Figure 1 shows the relative location of the creek, and the Dog River Watershed. Water hardness levels in Eslava Creek were compared to monthly average rainfall amounts from January 1999 to August 2007. When rainfall amounts in Mobile, increase, hardness levels are hypothesized to decrease in Eslava Creek due to the increase in the rate of the stream's flow. Stream flow is a major

determinant in water hardness (Interlandi and Crockett 2002). However, after extreme rainfall, as seen during flash flood events, the hardness level is believed to actually increase briefly, before decreasing, due to the large increase in weathering of concrete gabions and in the amount of run-off that makes its way into the stream. As rainfall levels decrease over time, hardness levels increase



due to the slowing of the stream's flow and the dissolved metals in the water being allowed to settle in place. Stream flow and hardness levels have an indirect relationship (USEPA 2000). Other studies across the world have found the similar results also.

Research Question

The major goal of the research is to find out if rainfall amounts can have an effect on the hardness values in Eslava Creek. I hypothesize that hardness levels will decrease as the rainfall totals for each month increase due to the increase in the stream's flow, while hardness levels will increase as the rainfall amounts decrease, due to a decrease in flow rates of the stream.

Methods

Hardness levels in Eslava Creek from January 1999 to August 2007 were obtained from the Alabama Water Watch organization website. The hardness levels were compared to the average monthly rainfall for the city of Mobile, obtained from the National Weather Service, to see if an indirect relationship could be found between the two variables. Bar graphs, scatter plots, and line graphs were used to show the indirect relationships. Other studies were also used to better understand the reasons for the outcome of the research.

Results

Increased Rainfall = Decreased Hardness

The hardness levels in Eslava Creek were found to be lower during prolonged periods of higher than normal rainfall amounts. Figure 2 shows that from January 2003 to August 2005, rainfall amounts are above average while, hardness levels in Eslava Creek are below average. For the most part of 2003, rainfall amounts trended towards above normal, while hardness levels trended towards below average levels. The same occurred for a brief time from April to August 2004. While the rainfall amounts were above normal in Mobile, Alabama, the flow of Eslava Creek would have been faster than normal due to the additional water in the stream. In a related study by the United States Environmental Protection Agency, hardness levels in a creek near San Diego were lower, while stream flow increased (USEPA 2000). Another study by scientists from the Philadelphia Water Department found that “river flow was the major determinant of daily variability in alkalinity, conductivity, hardness, and calcium levels (Interlandi and Crockett 2002).” I also produced a scatter plot to show the indirect relationship between the rainfall

amounts in Mobile and the hardness levels in Eslava Creek. Figure 3 shows that as above normal rainfall amounts increase, hardness levels actually decrease on an overall basis. The negative

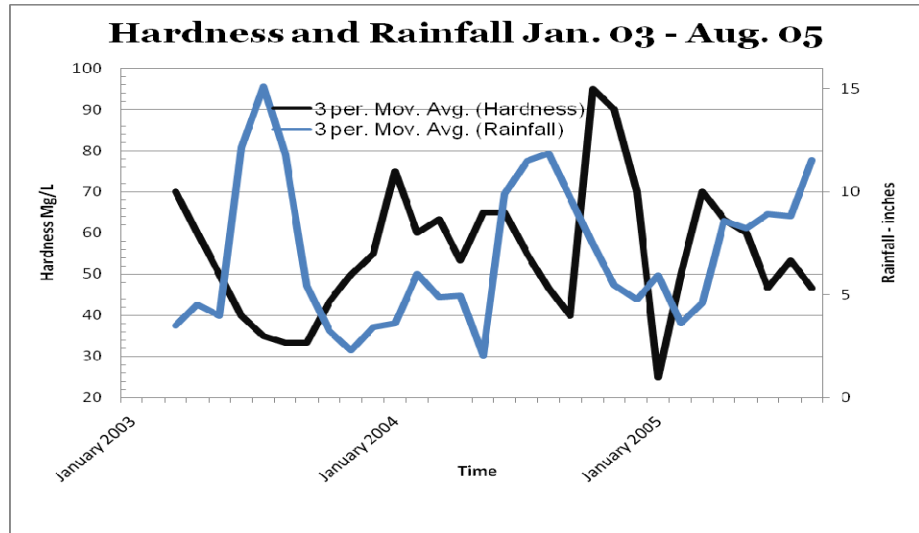


Fig. 2: Line chart showing the relationship between Rainfall and Hardness levels in Eslava Creek

trend line added to the scatter plot helps display the indirect relationship between the hardness in Eslava Creek and the rainfall in Mobile. Stream flow rate is the reason for the indirect relationship. An indirect relationship exists between flow rate and hardness such that higher flow rates correspond with lower hardness values, and lower flow rates often have higher hardness values (USEPA 2000).

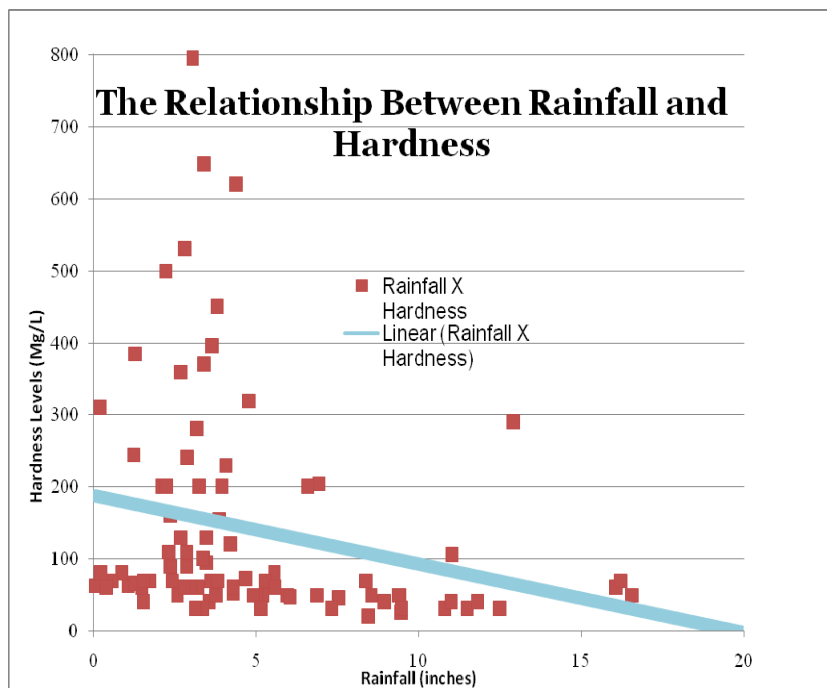


Fig. 3: Scatter plot of Rainfall and Hardness levels with a trend line included to show the indirect relationship between the two variables.

Decreased Rainfall = Increased Hardness

The study also showed that increased hardness values were found when rainfall amounts were at their lowest amounts. Figure 4 shows that the maximum hardness values were located at a time where Mobile received a less than average amount of precipitation. In a related study at the University of Mongolia, scientists found that a majority of streams in Ulaanbaatar City, Mongolia were found to have higher than favorable levels of hardness, while the flow rate in those same streams were lower than normal (Badrakh et al. 2008). High hardness values were observed in the EPA's study during lower flow rates in Southern California streams as well (USEPA 2000). Figure 4 shows that rainfall amounts decreased during late 1999 and early 2000, while hardness levels increased to their highest levels over a few years. This can also be contributed to a reduction in stream flow due to the lack of rainfall in the city. As the stream

slows, metals are allowed to dissolve in the water, which increases hardness levels. Another cause for an increase in hardness values could be salt water intrusion, which occurs during drought conditions. If fresh water is used

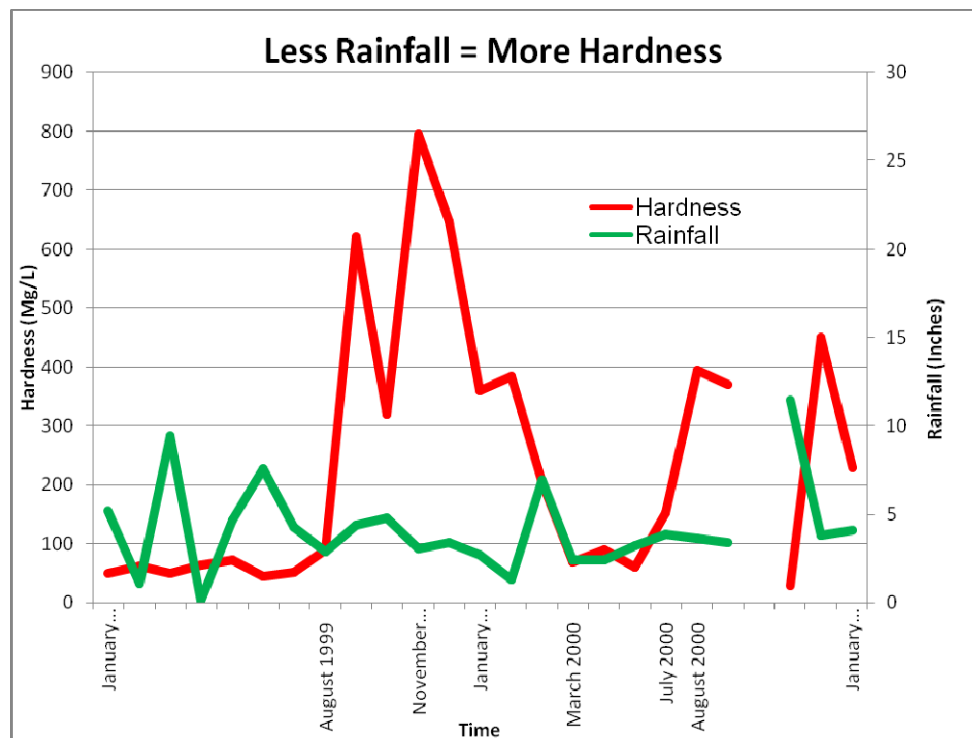


Fig. 4: Line graph showing less rainfall means Hardness levels increase.

from the streams faster than rain can replenish it, the water table is drawn down and hydrostatic pressure decreases, which causes salt water from the ocean to intrude into the fresh water aquifer (Elmhurst University 2008). When the city gets flood-like conditions, the hardness levels have different characteristics.

Floods Briefly increase Hardness

During the study, a surprise correlation was found. During periods of extreme rainfall maximums in the city of Mobile, hardness levels briefly increased before trending towards a more predictable level. In another study by scientists in Italy it was noticed that the concentration of heavy metals increased in an estuary of the Dese River during a flood in 2000 (Zonta et al. 2005). Figure 5 shows a brief jump in hardness just after maximums in rainfall, which resemble floods. In mid 2003 there is a spike in rainfall amounts in Mobile, Alabama, with an increase in hardness in late 2003. Again in mid 2004 there is a sharp spike in rainfall, with hardness spiking immediately after that and then returning to a more average level. At the end of the graph there is a third spike in late 2005, and hardness once again quickly spikes as the graph ends. As flooding occurs, run-off from the surface increases, which causes new metals to be thrown into the stream and briefly increase the hardness levels. As the newer metals rush through the stream with very high flow rates, the hardness levels then level off and return to a more predictable level. Another reason for the hardness increase could be increased weathering of rocks around the stream, due to the flooding conditions.

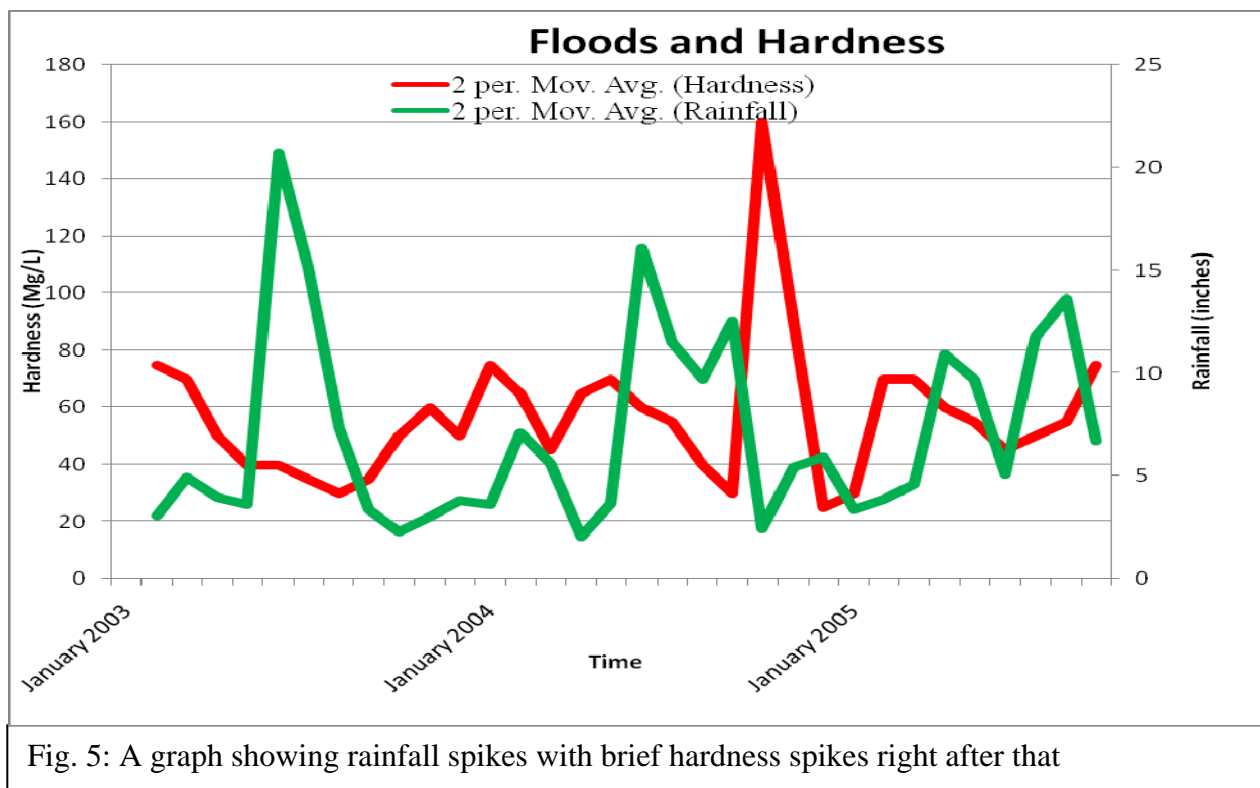


Fig. 5: A graph showing rainfall spikes with brief hardness spikes right after that

Discussion and Conclusion

This research was started as a way of educating the public on hardness levels and what could cause an increase or decrease in hardness levels. I found that in most cases, prolonged above normal rainfall conditions in Mobile, Alabama causes a decrease in hardness levels in Eslava Creek. The cause for this hardness decrease is the increase in the flow rate of the stream due to the increased rainfall amounts. As the stream moves faster the dissolved metals move downstream, decreasing hardness levels in the stream. As the stream slows, as happens when there is a prolonged decrease in rainfall, hardness levels increase due to metal being allowed to be dissolved. As surprise result was found when there were peaks in rainfall. Hardness levels briefly increased after flood-like conditions occurred in the Mobile area. Increased run-off and weathering of rocks close to the stream are the reasons for the brief increase in hardness. As that

increased run-off moves further down the stream the hardness levels begin falling again in most cases. The findings in this research can help readers have a better understanding of stream hardness and how precipitation affects streams in Dog River.

References Cited

- Auburn University and Global Water Watch. Alabama Water Watch. 2003-2008. Retrieved 19 February 2008 from <http://aww.auburn.edu/>.
- Badrakh, A., T. Tserendorj, D. Vanya, C. Dalaijamts, E. Shinee, T. Chultemdorji, R. Hagan, and S. Govind. 2008. A Study of the Quality and Hygienic Conditions of Spring Water in Mongolia. *Journal of Water and Health*, 6 (1): 141-148.
- Elmhurst University. Chemistry Issues and the Environment. Salt Water Intrusion. 2008. Retrieved 21 April 2008 from <http://www.elmhurst.edu/~chm/onlcourse/chm110/outlines/saltintrusion.html>
- Interlandi, Sebastian J. and Christopher S. Crockett. 2002. Recent Water Quality Trends in the Schuylkill River, Pennsylvania, USA. *Water Research* 37 (8): 1737-1748.
- National Oceanic and Atmospheric Administration and the University of North Carolina at Chapel Hill. Southeast Regional Climate Center. Monthly Precipitation Data for Mobile WFO. Retrieved 22 February 2008 from <http://www.sercc.com/cgi-bin/sercc/cliMONTpre.pl?al5478>.
- United States Environment Protection Agency. Newport Bay Toxics TMDL. Freshwater Flow and Seasonal Variation. Technical Support Document. 2000. Part B: 1-6.
- Wheelin Jesuit University. Water Quality Assessment: Chemical: Hardness. 2004. Retrieved 10 April 2008 from <http://www.cotf.edu/ete/modules/waterq3/WQassess3c.html>.
- Wurts, William A. Understanding Water Hardness. 2007. *World Aquaculture*, 24 (1): 18.
- Zonta, Roberto, Flaviano Collavini, Luca Zaggia, and Aleardo Zuliani. 2005. The Effects of Floods on the Transport of Suspended Sediments and Contaminants. *Environmental International*, 31 (7): 948-958.