# The Impact of the Roland Park Country School Stormwater Management System on Soil Calcium Levels





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**Abstract**

Calcium is a critical component of soil. It is essential to plants in forming cell walls, in performing cell division, and in determining the permeability of the cell membrane (Helper, 2005). While calcium is found in numerous soil minerals, including gypsum, superphosphate, amphibole, feldspar, marble, pyroxene, and apatite (Kelling and Schulte, 2004), limestone bedrock is one of its most significant sources in Eastern deciduous forests. Given that E.S.S.R.E Site 3 in Roland Park Country School sits on an exposed patch of limestone bedrock, and that the release valve for the stormwater management system empties the runoff from all artificial surface areas of the athletic center into Site 3, we hypothesized that this runoff might be dissolving the limestone is Site 3, thereby releasing calcium carbonate into the soil there and hence producing the high calcium concentration found in its surrounding soil. To test for the levels of calcium in Site Three, 9 vertical soil cores 2.5 centimeters in diameter and 15 centimeters in length were collected each day on July 22, 23, 26, 27, and 28, 2010. The samples included 3 taken along the streambed at the bottom of the hill, farthest from the water source, 3 more taken half way up the hill, and the final 3 taken from the top of the hill, closest to the water source. After testing for calcium levels with a LaMotte STH-14 chemical kit, our data showed that the RPCS stormwater management system is in fact causing the high calcium levels in E.S.S.R.E Site 3.

## Introduction

Calcium is a critical component of soil. It is essential to plants in forming cell walls, in performing cell division, and in determining the permeability of the cell membrane (Helper, 2005). It can also make soil more alkaline (Elmhurst College, 2003), thereby increasing the availability of other critical nutrients to plant life (Clemson University, n.d.).

While calcium is found in numerous soil minerals, including gypsum, superphosphate, amphibole, feldspar, marble, pyroxene, and apatite (Kelling and Schulte, 2004), limestone bedrock is one of its most significant sources in Eastern deciduous forests. This bedrock can be made up almost entirely of calcium carbonate (NZMIA, n.d.) and can contain anywhere from 22 percent (Dolomitic lime) to 54 percent calcium (slaked lime) (Kelling and Schulte, 2004). The calcium in this limestone is then regularly broken down by weathering when the carbonic acid found in rainfall dissolves it (Anthony Bennet, 2009). In fact, the rock is so easily eroded that karst topography- (underground water bodies, caverns, and sinkholes) is often formed (Anthony Bennet, n.d.). In addition, limestone bedrock can be eroded by water from storm runoff when stormwater management systems, with their buried holding tanks, release the water underground (Lake Superior Streams, 2010)

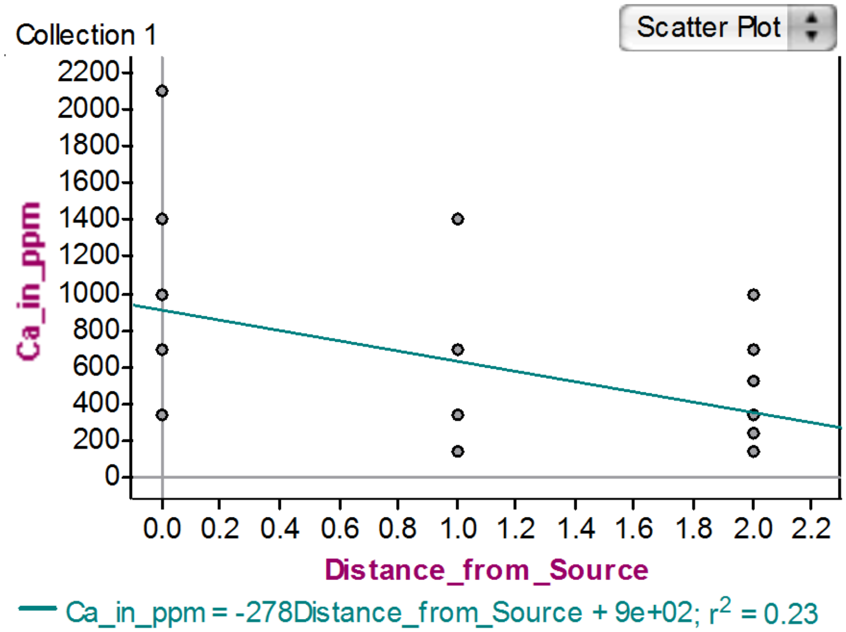
During the 2010 E.S.S.R.E. Biota Survey (E.S.S.R.E., 2010), unusually high calcium levels (1616 ppm) were found in E.S.S.R.E. Site 3 (E.S.S.R.E., 2001). Past years' data (E.S.S.R.E., 2010) show that the calcium levels in Site 3 have been increasing steadily since E.S.S.R.E. 2008, the year Roland Park Country School began construction on a new athletic center that is adjacent to Site 3. Given that Site 3 sits on an exposed patch of limestone bedrock, and that the release valve for the stormwater management system empties the runoff from all artificial surface areas of the athletic center into Site 3, we hypothesized that this runoff might be dissolving the limestone is Site 3, thereby releasing calcium carbonate into the soil there and hence producing the high calcium concentration found in its surrounding soil.

## Methods

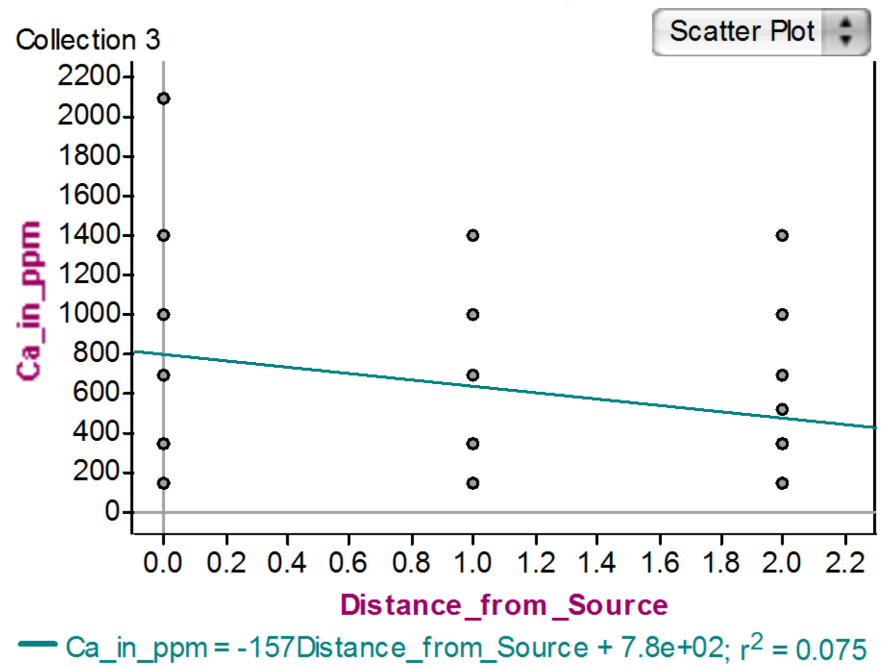
9 vertical soil cores 2.5 centimeters in diameter and 15 centimeters in length were collected each day on July 22, 23, 26, 27, and 28, 2010 from the E.S.S.R.E. Site 3 (E.S.S.R.E. 2001) for a total of 54 samples. Each day's 9 samples included 3 taken along the streambed at the bottom of the hill, 3 more taken half way up the hill, and the final 3 taken from the top of the hill. The first soil core taken along the streambed was taken in quadrant 2, the next was taken 10 meters downstream, and the final one was taken an additional 10 meters downstream from the second one. The 3 soil cores from the middle of the hill were taken in lines due southeast from each of the sampling locations along the streambed with 1 middle of the hill sample corresponding to each of the individual streambed samples. The final 3 soil cores were then taken at the top of the hill along the southeast lines from the previous sets of samples. All samples were then tested on the day of their collection for calcium levels in parts per million using the LaMotte STH- 14 kit.

**Results**

Graph 1: Distance from Stormwater Management Source Moving Downhill




Graph 2: Distance from the Bedrock Moving Downstream z



Graph 3: Comparison of Calcium Levels from Different Locations on the Hill

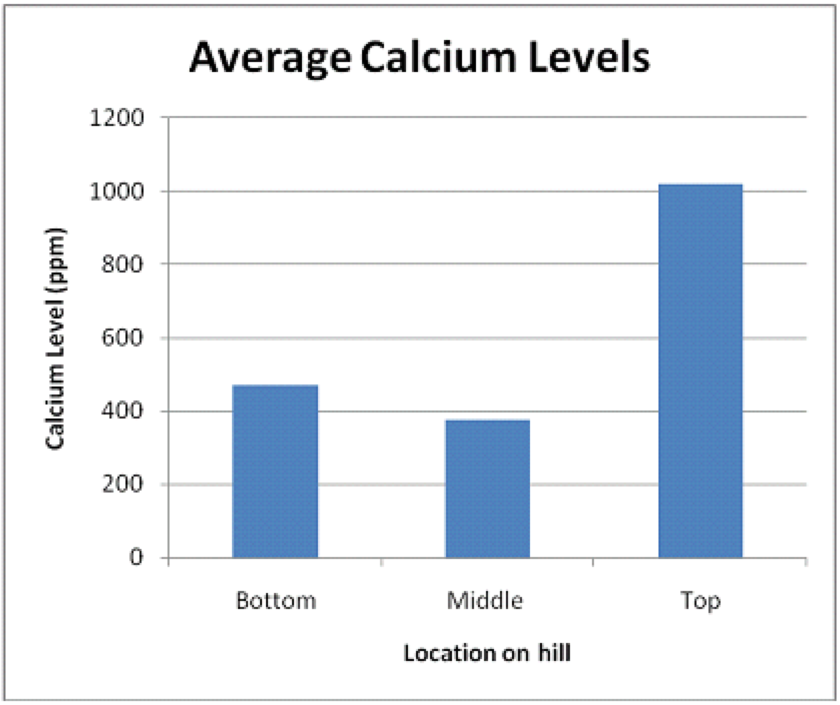



Table 1: T-testing Results for Data from Bottom, Middle, and Top Soil Sampling Locations

| Variables | P Value |
|---|---|
| Bottom vs. Middle | 0.363509229 |
| Bottom vs. Top | 0. 001806896 |
| Middle vs. Top | 0.00058097123 |

Table 2: T-testing Results for Data from Locations Moving Downstream

| Variables | P Value |
|---|---|
| B1, M1, and T1 vs. B2, M2, and T2 | 0. 229120732 |
| B1, M1, and T1 vs. B3, M3, and T3 | 0 .09306159 |
| B2, M2, and T2 vs. B3, M3, and T3 | 0.475870583 |

**Discussion**

As graph 3 shows, the calcium levels in the soil samples did correlate with the location of where the sample was taken on the hill. However, over the course of our research, we discovered that there are two possible explanations for this phenomenon. One is the original one of our hypothesis- that the stormwater management system, which releases its water underground at the top of the hill, is dissolving calcium from the limestone bedrock into the surrounding soil. But the other one we learned of is that fissures might have formed in the limestone bedrock itself when the blasting for construction of the nearby athletic center took place so that the higher levels of calcium might be due to natural groundwater moving through these fissures and dissolving the calcium instead.

We recognized that if the situation is the former, then the data should show significantly higher calcium levels along the entire top of the hill with a steady decline down the hill away from the stormwater source. If the situation is the latter, then the data should show the highest calcium levels in samples taken farther upstream with a steady decline in the calcium levels as you move downstream.

While our data supports both hypotheses to some degree (see graphs 1 and 2), the stormwater hypothesis is the one more strongly supported. Statistical analysis of the data reveals that while there is a 23% chance of the distance from the stormwater causing the differences in calcium levels ($r^2$= .23), there is only a 7.5% chance that the fissures in the limestone are causing the differences in calcium levels ($r^2$= .075). Hence, the stormwater explanation is the statistically stronger model for our data, making our stormwater hypothesis more likely.

Further support for this model can be seen from t-testing of the data. There was a significant difference between all the samples at the top of the hill and the remaining samples from the rest of the hill. While the p value between the samples from the bottom of the hill and the samples from the middle of the hill is only .363 (indicating that the data taken from the samples at the bottom and the middle of the hill were close enough in value to be considered the same population). The p value between the data from the bottom samples and the top samples (.002), and the p value between the middle and the top samples (.001) show that the higher calcium levels found along the top of the hill are statistically significant. Since calcium is not a leachable substance (Spectrum Analytic Inc., n.d.), the most likely source of the high levels of calcium found at the top of the hill versus the lower calcium levels found in the middle and the bottom of the hill is the water from the stormwater management system of the athletic center.

Furthermore, if the fissure hypothesis had been correct, the topography of the hill would make calcium levels upstream higher than the calcium levels found downstream. However, our data showed that the average calcium level for upstream was 455 ppm, while the average calcium level for downstream was 773 ppm. Moreover, the p value for this difference is 0.093, which shows that these differences are in fact statistically significant. Hence, the data contradicts the fissure hypothesis and our original hypothesis remains the most probably explanation for the original anomaly we observed.

Further experimentation on this matter could include how calcium levels affect plant life in Site 3 because this year's biota survey (E.S.S.R.E, 2010) also showed that the plant population in E.S.S.R.E. Site 3 (E.S.S.R.E., 2001) has been remaining more stable as calcium levels have risen over the past few years. Calcium could be stabilizing the plant life in Site 3 because, as we discussed earlier, it is an essential for plants in forming cell walls, performing cell division, and determining permeability of the cell membrane. It can also make soil more basic, which would make the soil more suitable for many types of plants and would increase the availability of other essential nutrients. Therefore, our logical next step would be to assess Site 3 to see if there is a correlation between plant health and calcium levels in the soil there.

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