Phosphorus: the Mystery Solved

Emma Craig, Gabriella del Hierro, Rachael Ohale and Alyssa Wellman Houde

Abstract

In our experiment, we tested the levels of phosphorus along the banks of a stream, located in the backwoods at Roland Park Country School. The purpose of our experiment was to explain why the phosphorus levels were higher in one area of the woods (ESSRE 2011 Site 4) than in the others. We hypothesized that this was because of weathering bedrock in the stream and the leaching of phosphorus into the water flow. For five days, we took two samples on opposite sides of the river at six different locations. We then tested the samples for phosphorus using the LaMotte Combination Soil Outfit Model STH-14. After the five days of testing, we found that our hypothesis was supported by the data, but may have been affected by outside factors, such as rain.

Introduction

Phosphorus is one of the three nutrients (along with potassium and nitrogen) that is essential to plant growth (Bushman, Lowell, John Lamb, Gyles Randall, George Rehm, and Michael Schmitt, 2002). It helps plants carry out photosynthesis by acting as a building block for ATP, DNA and RNA, and plants with phosphorus deficiencies are often stunted and can have abnormal coloring. Phosphorus also affects algae levels in bodies of water. Low levels of phosphorus usually result in low algae levels, while high levels of phosphorus can cause destructive algal blooms. Phosphorus's effect on algae and plant life can in turn affect animal populations as the chemical element moves up the food chain. (Ophardt, Charles E., 2003)

Organic forms of phosphorus originate as inorganic phosphorus salts found in rocks, and it is through the weathering of rocks that phosphorus becomes available for plant use. Precipitation leaches phosphorus from the rocks, which is then deposited in the soil through sedimentation. The plants then absorb the phosphorus through their roots where it is transformed into forms plants and their consumers can use, and this organic form eventually returns to the soil as feces and decaying plant and animal matter where it is recycled (Environmental Literacy Council, 2002).

Accumulated data from the Environmental Science Summer Research Experience has shown that in E.S.S.R.E Site 4 (N 39.35733; W 076.63840) phosphorus levels have increased steadily over the past 10 years (E.S.S.R.E., 2001-2011). Site 4 is adjacent to E.S.S.R.E Site 3 (N 39.35797; W 076.63836) in which a small spring-fed stream is present that flows into Site 4.

The section of the stream in Site 3 is extremely rocky and has many changes in the current of the stream due to uneven terrain (see Figure 1) which then levels out into the flattened terrain of Site 4 (see Figure 2). We hypothesized that the increase of phosphorus in Site 4 may be due to the presence of exposed bedrock in Site 3. Erosion is a known cause of weathering (Planet Dictionary, 2008), which led us to predict that the water in the stream is leaching the phosphorus out of the bed rock where it travels to Site 4 and is deposited in the nearby soil.

Figure 2

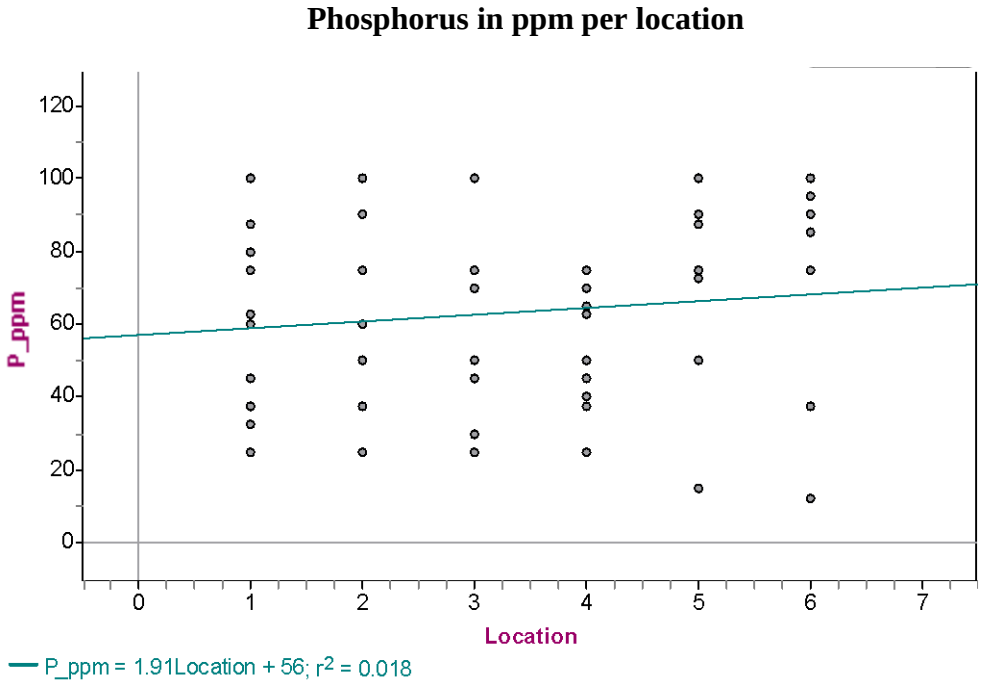
Figure 1

Methods

6 pairs of flags were placed along the streambed running through quadrant 2 and 3 of E.S.S.R.E Site 3 (N 39.35797; W 076.63836). Starting at the boundary of quadrant 2, the first pair of flags was placed on opposite sides of the stream. Five additional pairs of flags were placed 10 meters downstream of the first pair, each pair placed at 10m intervals from the previous pair. All flags were placed in the soil at the boundary between the bedrock and the bank of the stream. At each flag location, a soil core sample 15cm deep and 2.5cm in diameter was taken using a metal soil auger. All 12 samples were tested for phosphorous (ppm) using the LaMotte Chemical Test Kit Model STH-14 on the same day the soil samples were taken. Both sampling and chemical testing were completed a total of five times, once daily on each of the following dates: July 21st, 22nd, 25th, 26th and 27th 2011.

Results

Graph 1:



Location 1: flags 1 and 2

Location 2: flags 3 and 4

Location 3: flags 5 and 6

Location 4: flags 7 and 8

Location 5: flags 9 and 10

Location 6: flags 11 and 12

Figure 3:

T-Testing

Location	P-values	Yes/No/Strongly Significant
1-2	.76869	No
1-3	.68028	No
1-4	.38048	Strongly Significant
1-5	.35465	Strongly Significant
1-6	.42573	No
2-3	.48596	No
2-4	.20883	Strongly Significant
2-5	.49869	No
2-6	.57488	No
3-4	.73694	No
3-5	.20771	Strongly Significant
3-6	.26251	Strongly Significant
4-5	.06546	Yes
4-6	.10963	Yes
5-6	.95414	No

Discussion

Our hypothesis was supported. As graph 1 indicates, samples taken at the highest elevation in the stream had considerably less phosphorus (ppm) than those samples taken farther downstream, indicating that leaching and the accumulation of phosphorus from the exposed bedrock in Site 3 is taking place further downstream. Furthermore, p- values (see Figure 3) show that there was a strong statistically significant difference between the data collected at the top of the stream (locations 1 and 2) and the data collected from the bottom of the stream (locations 3 through 6). Both the p-values and the average phosphorus levels found at locations 1 through 3 (50.4 ppm to 49.58 ppm on average) show that there is little difference in the amount of phosphorus found in the first 3 locations. But this is to be expected given that there is a drop of about 3 meters in elevation over a distance of 20 meters between locations 1 and 3. This decline causes the water to move a little more rapidly over the rocks, giving less time for the phosphorus to leach out of the bedrock. Meanwhile, the topography in locations 4 through 6 is fairly flat.

This even terrain area allows the water to flow at a slower rate, and gives the water more time to leach the phosphorus out of the bedrock, which is supported by the amount of phosphorus found in locations 3 through 6 (49.58 ppm through 58.96 ppm on average). Based on our findings, we would monitor the phosphorus levels for a longer period and expand our testing site to include locations upstream and downstream from our research site.

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