# The Influence of Stream Flow on the Moisture and Phosphorus Levels in the Adjacent Soil

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## Abstract

The element phosphorus is a critical component of living things, providing the raw material for amino and nucleic acids. Therefore any changes in its accessibility can have a significant impact on an ecosystem. Consequently, we became interested in discrepancies in soil phosphate levels observed in the E.S.S.R.E. 2015 Biota Survey. A 3x5 sampling grid was created and 15 soil samples15 centimeter deep and 2 centimeters in diameter were extracted at each location in the grid; simultaneously, the stream location next to each row was tested for phosphate using the Hach Aquachek Water Quality Test. All 15 soil samples were then tested for phosphorous (ppm) using the LaMotte model STH-14 test kit, and 15 samples were tested for percent moisture content using the gravimetric method. Our results showed that that the distance from the stream did have an effect on the amount of phosphorus but that the moisture levels were not the most dominant factor in causing an increase in the levels of soil phosphorus. For further studies on phosphorus levels, we would examine the relationship between the plants and the soil at the research site. We would test the phosphorus levels in the plants as well as the adjacent soils to determine if it was the uptake of phosphorus by plants that was affecting the levels of phosphate in the soil.

## Introduction

Phosphate makes up almost all of the forms of natural phosphorus in the Earth's crust as well as in the world's oceans and other bodies of water, and it is an essential nutrient for all living things that is recycled in a process called the phosphorus cycle. The weathering of rocks first releases active forms of phosphorus, distributing it into the soil and water (Hogan, C.M. 2012), and it is from the soil that phosphorus enters the food chain through its absorption by plants. From the plants, the phosphorus is passed along to animals and the decomposers, which will eventually release it back into the soil where the phosphorus will cycle through again.

Because the element phosphorus is a critical component of living things, providing the raw material for amino and nucleic acids, any changes in its accessibility can have a significant impact on an ecosystem. Consequently, we became interested in discrepancies in soil phosphate levels observed in the E.S.S.R.E. 2015 Biota Survey (ESSRE, 2015 a). The result of this survey revealed that the average amount of phosphorus in E.S.S.R.E. Microclimate 4 (N 39.35733; W 076.63840) was 120.8 ppm; while the average levels found in E.S.S.R.E. Microclimates 1 (N 39.35794; W 076.63977), 2 (N 39.35740; W 076.63893), and 3 (N 39.35797; W 076.63836) were 27.9 ppm, 12.7 ppm, and 20.6 parts per million respectively. Since all four microclimates lie along a tributary of the Jones Falls River watershed in Baltimore, Maryland, significantly higher phosphorus levels in Microsite 4 made us postulate that something about the flow of water through these sites and the consequent erosion might be the source of this discrepancy. Furthermore, because Microclimate 4 lies downhill along a steep slope of exposed rock, it is possible that the stream flowing through Microclimate 3 into Microclimate 4 weathers the rocks, causing any phosphorus present to dissolve into the water and be carried downstream.

Most significantly, water from the stream pools in Microclimate 4. Hence, we began to suspect that the high levels of phosphorus historically found in this location (ESSRE, 2015 b) may be coming from the stream, which floods after heavy rain showers. It is known that the amount of moisture in soil can affect the uptake of phosphorus from the soil by changing the growth of the plant roots (Gahoonia, Tara; Raza, Sherow; Nielson, Niels), and we suspect that there is more moisture in the soil closer to the stream due to the regular pooling of water in Microclimate 4 and that the moisture will decrease in the soil farther away from the stream bed. We also suspect that the soil which contains more moisture will contain more phosphorus since the stream water contains high phosphorus levels and may spread it through the soil. Therefore, we hypothesized that the historical abundance of phosphorus in this location is due to the placement of the site in relation to the stream and that soil close in proximity to the stream will process higher percentages of moisture and as a consequence, phosphorus levels. Hence the further away from the stream soil is collected and tested for the lower level of phosphorus and soil moisture we expect to find.

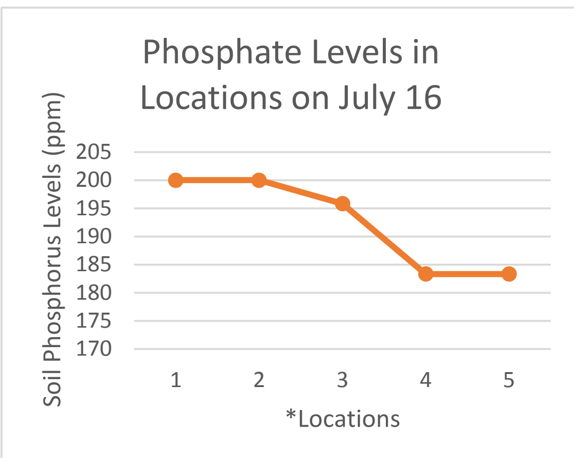
## Methods

In E.S.S.R.E. Site 4 (N 39.35733; W 076.63840), a 3x5 sampling grid was created for collecting soil samples to test for phosphorus and percent moisture levels. Flags were used to mark the grid locations starting with a flag at the midpoint to orient the grid. 4 additional sampling sites were flagged at 2 meter intervals in a line due south of the mid-point away from the stream bed. 2 more rows of 5 flags were placed in the soil parallel to this original set, one 2 meters due east and one 2 meters due west. 3 soil samples 15 centimeter deep and 2 centimeters in diameter were extracted at each flag location. Simultaneously, the stream location next to each row was tested for phosphate using the Hach Aquachek Water Quality Test.

Following collection, all 15 soil samples were then tested for phosphorus (ppm) using the LaMotte model STH-14 test kit, and 15 samples were tested for percent moisture content by first allowing all samples to air dry and then heating them at 105° Celsius for 24 hours. The sampling process and all chemical and moisture tests were completed a total of 4 times on 4 separate days; July 16th, 17th, 20th and 21st of 2015.

**Results**

Graph #1




Graph #2

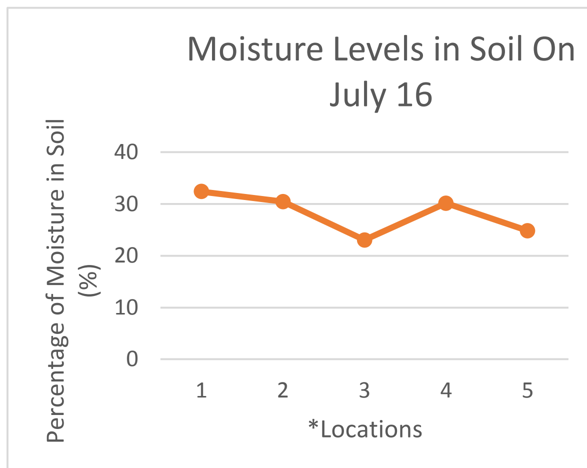



Table #1

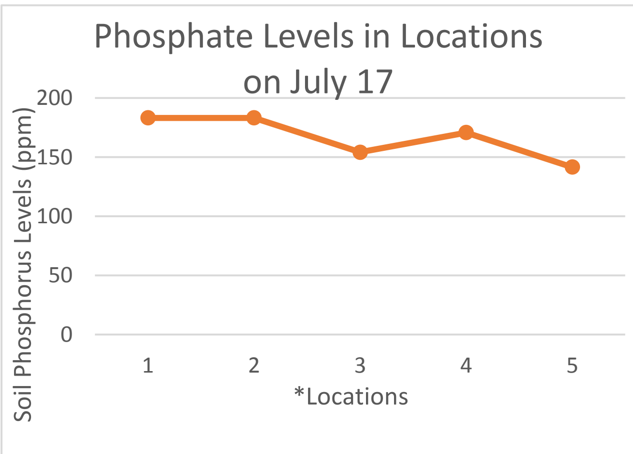
| Phosphorus p-values | | |
|---|---|---|
| Day | Location | p-value |
| 7/16 | 1-2 | / |
| | 1-3 | 0.4226 |
| | 1-4 | 0.4226 |
| | 1-5 | 0.4226 |

Table #2

| Moisture p-values | | |
|---|---|---|
| Day | Location | p-value |
| 7/16 | 1-2 | .8777 |
| | 1-3 | .3955 |
| | 1-4 | .8130 |
| | 1-5 | .6681 |

Table #1 shows the p-values between location 1 and each of the other 4 locations for the phosphorus levels on the first day. Table #2 shows the p-values between location 1 and each of the 4 other locations for the percentages of moisture in the soil on the first day. All p-values were calculated using 2-variable t-testing.

Graph #3




Graph #4

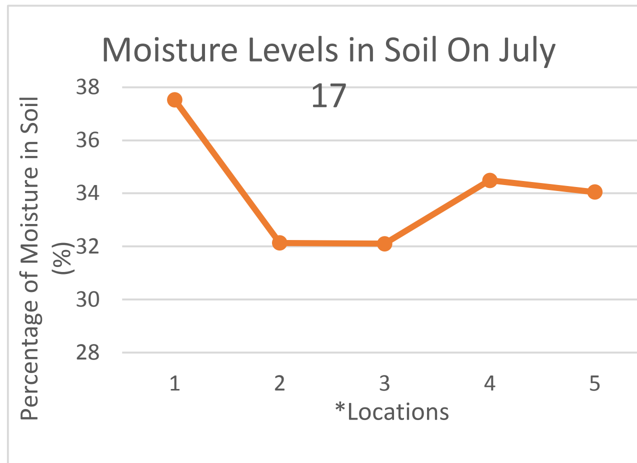



Table #3

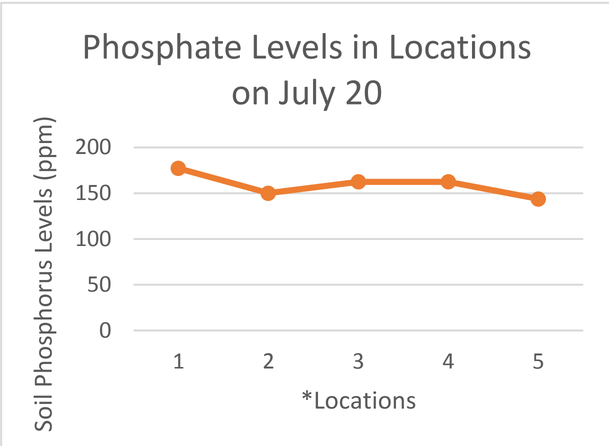
| Phosphorus p-values | | |
|---|---|---|
| Day | Location | p-value |
| 7/17 | 1-2 | 1 |
| | 1-3 | 0.2286 |
| | 1-4 | 0.4578 |
| | 1-5 | 0.1131 |

Table #4

| Moisture p-values | | |
|---|---|---|
| Days | Location | p-value |
| 7/17 | 1-2 | 0.491 |
| | 1-3 | 0.295 |
| | 1-4 | 0.394 |
| | 1-5 | 0.342 |

Table #3 shows the p-values between location 1 and each of the other 4 locations for the phosphorus levels on the second day. Table #4 shows the p-values between location 1 and each of the 4 other locations for the percentages of moisture in the soil on the second day. All p-values were calculated using 2-variable t-testing.

Graph #5




Graph #6

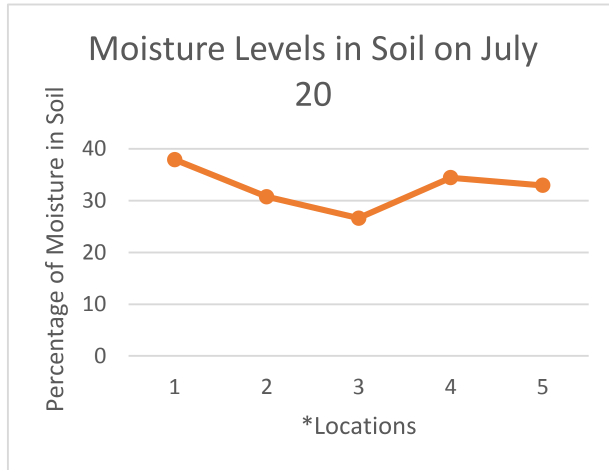



Table #5

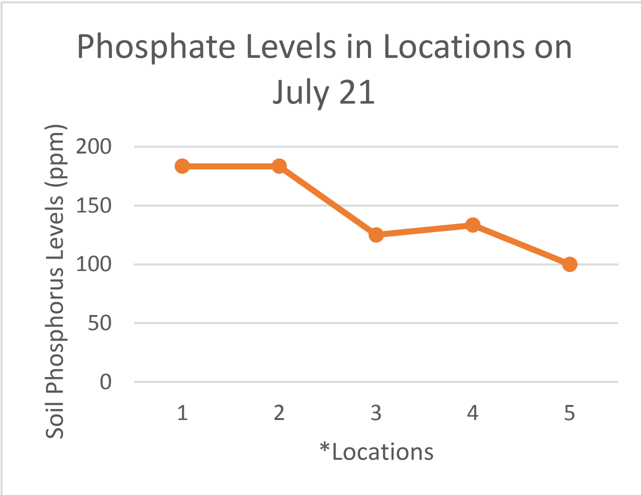
| Phosphorus p-values | | |
|---|---|---|
| Days | Location | P-value |
| 7/20 | 1-2 | 0.503 |
| | 1-3 | 0.649 |
| | 1-4 | 0.649 |
| | 1-5 | 0.424 |

Table #6

| Moisture p-values | | |
|---|---|---|
| Days | Location | P-value |
| 7/20 | 1-2 | 0.491 |
| | 1-3 | 0.295 |
| | 1-4 | 0.394 |
| | 1-5 | 0.342 |

Table #5 shows the p-values between location 1 and each of the other 4 locations for the phosphorus levels on the third day. Table #6 shows the p-values between location 1 and each of the 4 other locations for the percentages of moisture in the soil on the third day. All p-values were calculated using 2-variable t-testing.

Graph #7




Graph #8

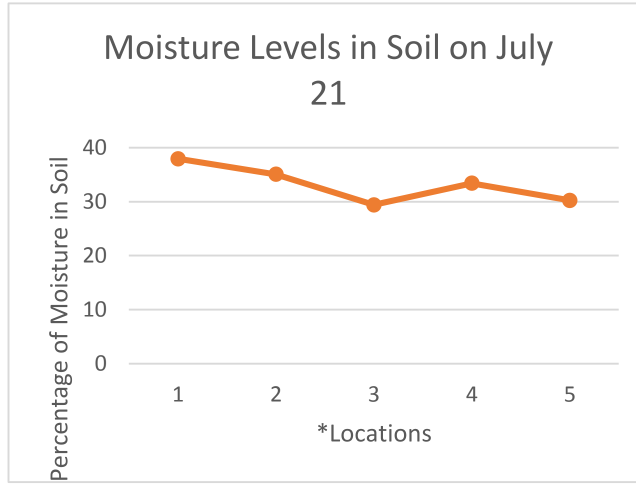



Table #7

| Phosphorus p-values | | |
|---|---|---|
| Days | Location | P-value |
| 7/21 | 1-2 | 1 |
| | 1-3 | 0.264 |
| | 1-4 | 0.150 |
| | 1-5 | 0.059 |

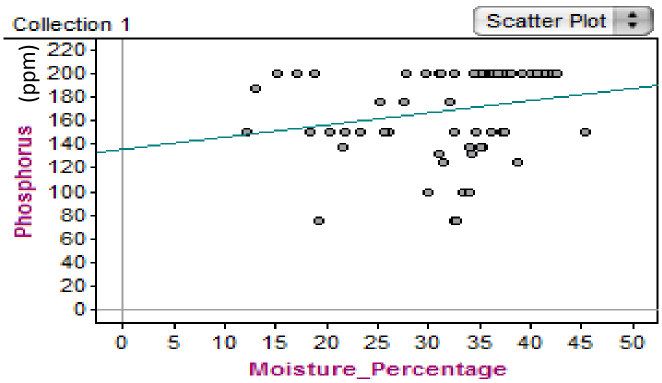
Table #8

| Moisture p-values | | |
|---|---|---|
| Days | Location | P-value |
| 7/21 | 1-2 | 0.7088 |
| | 1-3 | 0.3370 |
| | 1-4 | 0.5110 |
| | 1-5 | 0.2781 |

Table #7 shows the p-values between location 1 and each of the other 4 locations for the phosphorus levels on the fourth day. Table #8 shows the p-values between location 1 and each of the 4 other locations for the percentages of moisture in the soil on the fourth day. All p-values were calculated using 2-variable t-testing.

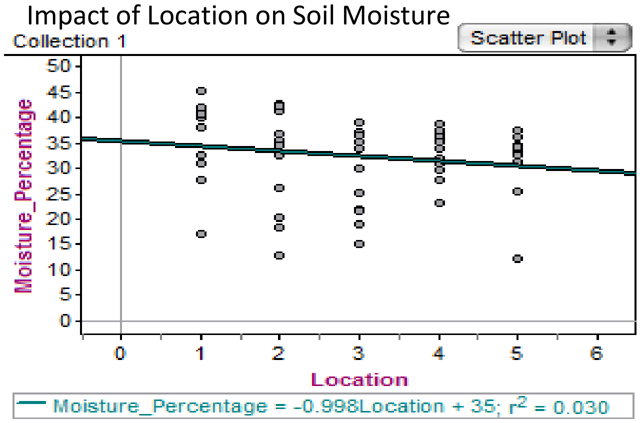
*The locations represent the different distances away from the stream, 1 being the closest and 5 being the furthest.

Impact of Soil Moisture on Soil Phosphate Levels



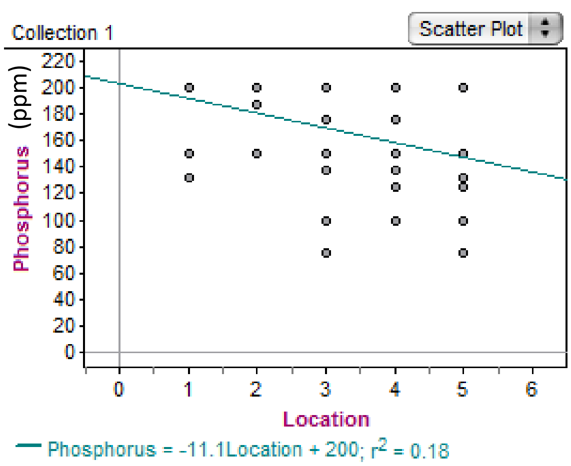

Graph #9

Impact of Location on Soil Moisture




Graph #10

Impact of Location on Soil Phosphate Levels




Graph #11

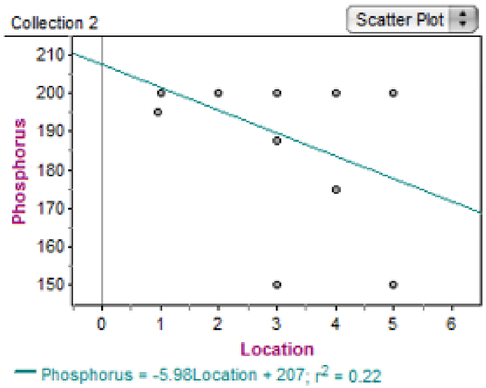
**Discussion**

Statistical analysis of all 4 days of phosphate data revealed that soil samples collected on July 16th and July 20th showed no statistically significant correlation between the levels of phosphate observed in the 5 locations at different distances from the stream bed (all $p > 0.20$; see Tables 1 and 5). Therefore, as shown in Graphs 1 and 5, the phosphate levels were statistically essentially the same no matter how far the soil samples were taken from the stream. Additionally, the statistical analysis of all 4 days of moisture data revealed that soil samples collected on July 16th and July 20th showed no statistically significant correlation between the levels of moisture observed in the 5 locations at different distances from the stream bed (all $p > 0.20$; see Tables 2 and 6). Therefore, as shown in Graphs 2 and 6, the moisture levels were statistically essentially the same no matter how far the soil samples were taken from the stream.

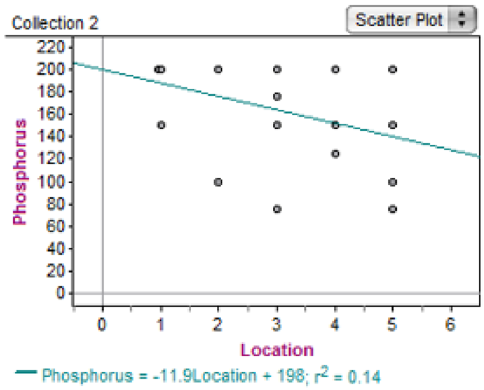
However, on July 17th, the phosphate levels showed the anticipated decline between locations 1 and 2 and location 5, and the decline was statistically significant ($p=0.1131$). A weaker expected correlation was observed in the moisture levels in the soil on July 17th between location 1 and location 3 ($p= 0.295$), location 1 and location 4 ($p= 0.394$), and location 1 and location 5 ($p= 0.342$). Therefore, on July 17th, the data suggests that it supports our supposition that the moisture and phosphorus levels in the soil were in direct correlation with each other but fails to do more than suggest such support. Likewise, on July 21st, the phosphate levels showed the anticipated decline between locations 1 and 2 and location 4 ($p=0.159$) and a stronger anticipated decline between locations 1 and 2 and location 5 ($p=0.059$). But again, a weaker correlation was observed in the moisture levels in the soil on July 21st between location 1 and location 3 ($p= 0.3370$) and location 1 and location 5 ($p= 0.2781$). Therefore, on July 21st, the data again only *suggests* support for our supposition that the moisture and phosphorus levels in the soil were in direct correlation with each other.

Furthermore, when potential correlations are examined across all data sets with respect to the distance from the stream bed and the percent of moisture, Graphs 10 and 11 show the expected inverse correlation but not significantly ($r^2= 0.030$, $r^2= 0.18$). In addition, while the expected correlation between the percentage of moisture in the soil and the phosphorus levels in the soil were observed (see Graph 9), again the expected relationship was not statistically significant ($r^2= 0.049$). Therefore, while our hypothesis is somewhat supported by both the daily data and the collective data, neither the calculated $r^2$ values nor the p values were high enough to confirm our hypothesis.

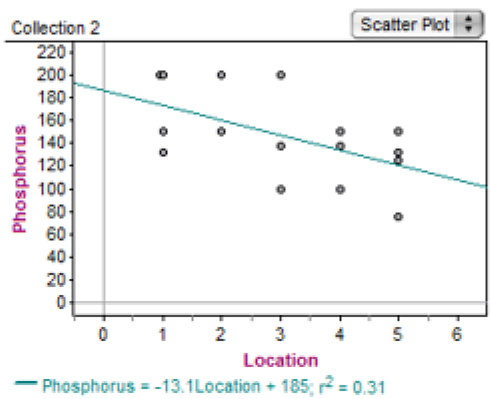
However, a more detailed analysis of the individual rows of data revealed a potential explanation for a more likely explanation than soil moisture levels for the observed drop in phosphorus levels in Graph 11. As Graphs 12-14 of the sets show, there was a difference in the amount of phosphorus observed along each row of data that corresponds to the amount of plant life found in each location.




Graph #12: Set A




Graph #13: Set B




Graph #14: Set C

The density of the plant life was greatest in the area corresponding to Graph 14, and with such a high $r^2$ value (0.31), we now believe that differences in plant life in Microclimate 4 is the more likely cause of the differences in the phosphorus levels observed in the E.S.S.R.E. 2015 Biota Survey (ESSRE, 2015).

In the future, we recommend exploring this possible correlation between the density of plant life and the phosphorus levels in the soil in Microclimate 4 by testing for phosphate levels in the plants and the phosphate levels in the soil adjacent to the plants, as well as still determining the percentage of moisture in the soil to see its impact on both plant life and soil phosphorus levels.

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**Acknowledgements**

We would like to thank the following funders of the Environmental Summer Science Research Experience: Dr. Holliday Cross Heine, The Jennings Family, and Human Capital Development, Inc. We would also like to say thank you to our Internship Director, Mr. Brock, for helping us throughout our research.