Does rhododendron have an effect on the levels on iron and pH in soil?

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Abstract

The fact that Fe(OH)3 is the form of iron that is found on the soil. As the pH level goes down there are more hydrogen ions in the soil. In turn the hydrogen ions extract the hydroxides from the iron thus creating more iron in the soil. This led us to believe that there was a connection between iron and pH levels. The site in which we were working had a high population of rhododendron. After research we found that the rhododendron plant is and acidic loving plant. The purpose of our experiment was to find out if there was a connection between the rhododendron and then abnormal results of pH and iron levels. We took 15 samples from 5 different areas of varying density of rhododendron. We performed chemical test for pH and iron. The tests showed that there is relationship between high iron and low pH. After analyzing the data we found the rhododendron itself does not have any affect what so ever on the levels of pH and iron in the soil. But after further research we found that a fungus that lives inside the cell of the hair root of the plant might be causing the high levels of Ferric iron in the soil.

Introduction:

In part of doing the biota survey for the Environmental Science Summer Research Experience at Roland Park Country School it was seen that the iron and pH levels were not normal. Site three (N 39.35797; W 076.63836) has a steep hillside that grows rhododendrons, ferns, and English ivy. Due to the erosion within the site only limestone bedrock remains. Most of the soil in site three this year consists of silt. Site two (N 39.35740; W 076.63893) has a lot of undergrowth within the site, and has a large population of English ivy. Site 4 (N 39.35733; W 076.63840) has little plant diversity in the site, and has a stream spread out through the site. It was found that during the soil biota survey and chemical testing of site three that site three had a soil pH of 5.6. The soil pH of site four was 6.9, and the soil pH of site two was 5.8. This means that the soil in site three is twenty times more acidic than the soil pH in site two, and a hundred times more acidic than the soil pH in site four (E.S.S.R.E, 2005). The soil pH of site three was significantly different from the other two sites' pH. The reason why the pH levels are so important is because when the pH is lower the acid in the soil destroys some of the vital nutrients obtained from the soil by the plants. Thus, when soil pH is low some plants cannot obtain crucial elements that are needed for growth (Donald Bickelhaupt ,n.d)

In addition to having significantly higher acidic soil, site three also had a significant difference in iron levels from the other two sites. Site three had an average iron level of 16.42 ppm compared to site two which had an average iron level of 7.08 ppm and to site four which had an average iron level of 2.70 ppm. There are some unique features to site three that might explain why pH and iron levels are so high. Iron is vital for plant growth, but is only needed in small amounts. Iron is a crucial element because it is responsible for chlorophyll synthesis. Too much iron can be harmful because it can hinder the uptake of other elements and vital nutrients. (Nay, 2005). Site three has a stream that goes through it, and also has a steep hill. The basic material from which the soil was developed has an affect on the soil pH level. When rainfall and moving water pass through soil it stripes the soil of certain elements and replaces them with more acidic elements such as iron and aluminum (Kluepfel and Lippet, n.d). The fact that site three has a stream running through it might be the reason as to why site three has high iron and low pH levels. The stream could be inserting acidic elements into the soil. As likely as it seems that the stream might be the cause to high pH and iron that is not the case. Site two also has a stream running through the site. Since site two has a stream it should have high levels of iron and low levels of pH, but site two did not have high iron and low pH levels.

Another distinct feature to site three is the growth of rhododendrons. Rhododendrons grow in acidic areas because of their need for iron. Rhododendrons are likely to develop an iron deficiency when the pH is higher than 7 (Horne, 2002). The fact that site three is the only site that has rhododendrons growing led us to question if it was the rhododendrons that are affecting the iron and pH levels within the soil. According to Donald Bickelhaupt from the SUNY College of Environmental Science and Forestry (n.d) soils with a high acidic level have high levels of iron. As pH decreases iron levels increase because iron becomes more soluble as pH decreases. The form of iron that exists in soil is Fe(OH)3. As pH decreases there are more free floating hydrogen ions [H+]. Since the iron has hydroxides [OH-] attached to it, the free floating hydrogen ions leech the hydroxides away from the iron. This creates more iron in the soil (Hersey ,2001).

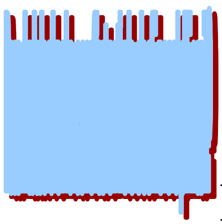
Fungi and plants form a relationship in which fungi enter into the Rhododendron's hair root cells. In this ericoid mycorrhizal relationship the fungi go into the plant's hair root cell, once this happens there is an exchange amongst nutrients and energy amongst the fungi and plant (University of Wisconsin Madison, 2002). Mycorrhiza fungi help with bringing the plant nutrients that otherwise they would not receive by themselves. Because of this relationship the mycorrhiza fungi bring iron to the plants that they would not normally receive in order to function (Haselwandter, 2003). Since the mycorrhiza are bringing iron to the plants, that they otherwise would not receive might be the reason for the high levels of iron in the soil.

For our experiment we chose 5 sites of varying rhododendrons density. The reason for finding sites with vary rhododendron density is that it will help prove our hypothesis that the rhododendrons are affecting the soil pH and iron levels. The more rhododendrons there are the higher the levels should be because the fungi within the rhododendron's hair root cells are bringing the iron to the plant. It is logical the presume that the more rhododendrons there are the higher the iron will be and the lower the pH will be. The more rhododendrons there are in an area there will be a total larger number of fungi bringing iron to the plant. Thus creating more iron within the site of varying rhododendrons. For each of the five sites of varying rhododendrons density we took three soil samples. We then took the soil samples back and tested them for pH and iron levels to see if it was actually the rhododendrons causing the high pH and iron levels in the soil.

Methods and Materials

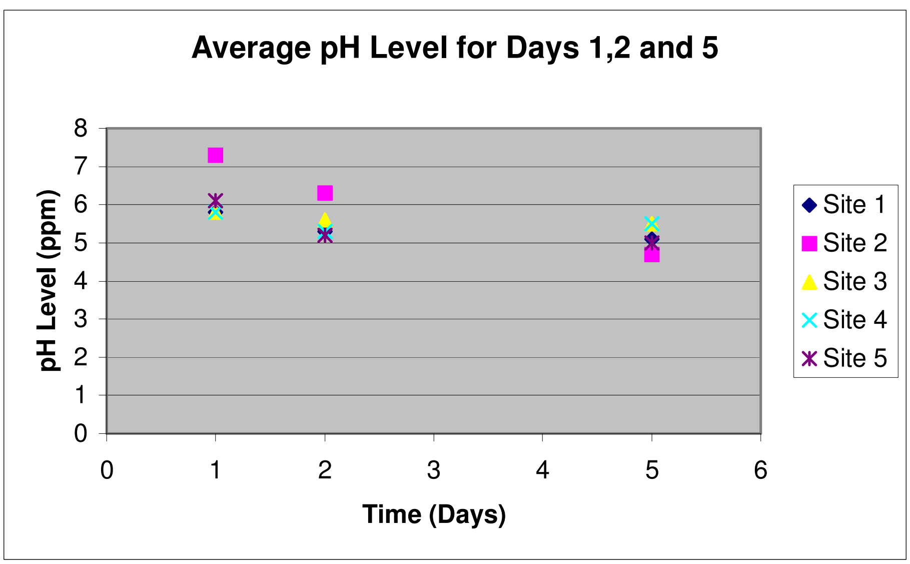
We took 15 different samples of dirt from 5 different plots off a hillside (at the top of the campus which is heavily forested) near a stream and inhabited with rhododendrons (N 39.35797; W 076.63836). The area has many ferns and opaque patches of English Ivy. The five plots contained varying densities of rhododendron plants. We constructed the 5 plots with flags by using a measuring tape to form perfect squares. Each flag is two meters apart from the next flag, creating 2 meter by 2 meter squares. After the plots were constructed, we counted the rhododendrons inside the plots. Instead of counting the stems of the rhododendrons, we counted the actual roots of the plants. We then recorded where the plots were in the site and how many rhododendrons were inside each of the plots.

We took three soil samples from each of the five plots (15 samples total). The location from where the soil samples were taken was randomly selected. We used soil corers (15 cm deep and 2 inch diameter) were used to take dirt and put into labeled plastic bags. We used the LaMotte STH Series of professional soil testing outfits to test each soil sample for their pH and iron levels. We tested the soil samples for both the factors at the same time for 3 days over the course of 5 days.



Results

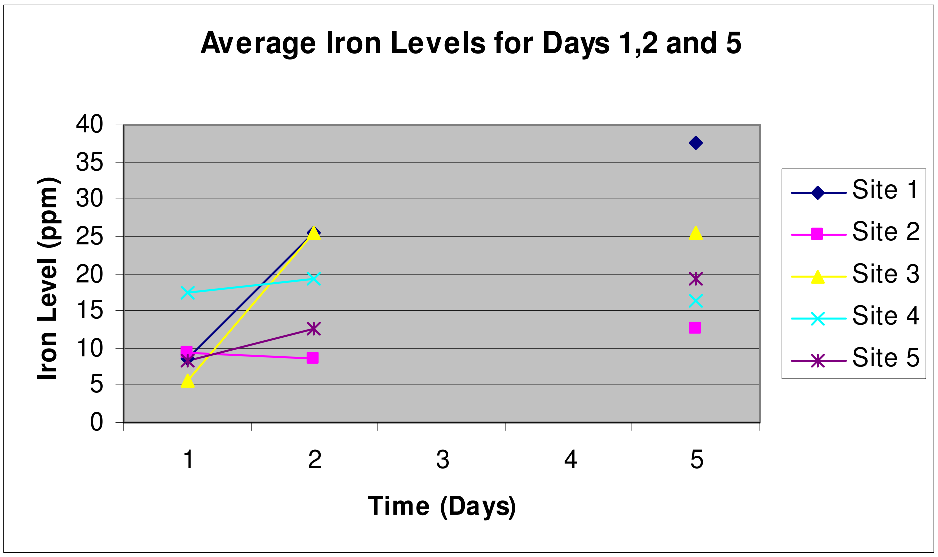
Graph 1



The averages show that over the 5 days we tested the soil samples, the pH level in the soil went down and the level of iron in the soil went up. Graph 1 shows the average of the pH level for all three days that the chemical testing occurred. It is clear that over time the level of pH is going down for site three.

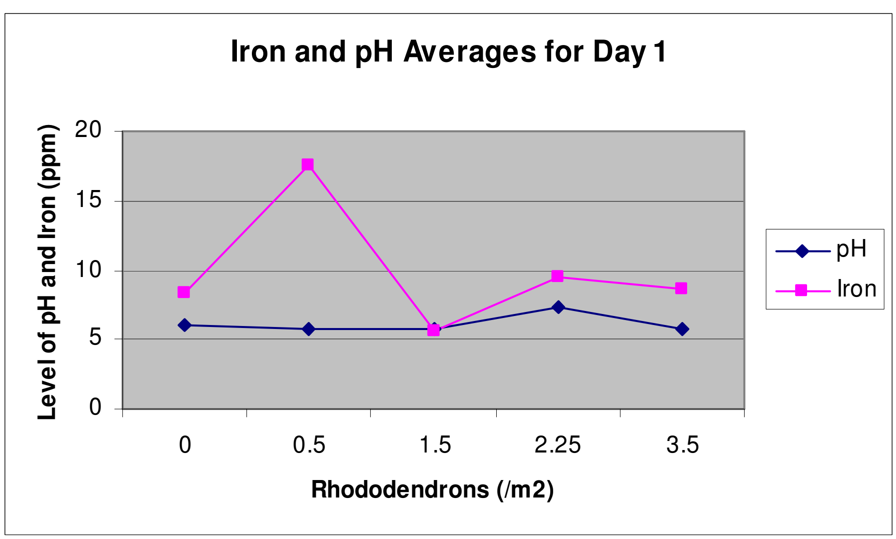
According to graph 2 it is also clear that the iron level for site 3 was going up over time, for plot 1,3,4, and 5, the level went down for site 2.

Graph 2



According to graph 3 there is no relationship between the density of the rhododendron and the level of pH and iron in the soil. As the density increases there is no real consistent pattern to the change in how much iron and pH there is in the soil.

Graph 3



Discussion

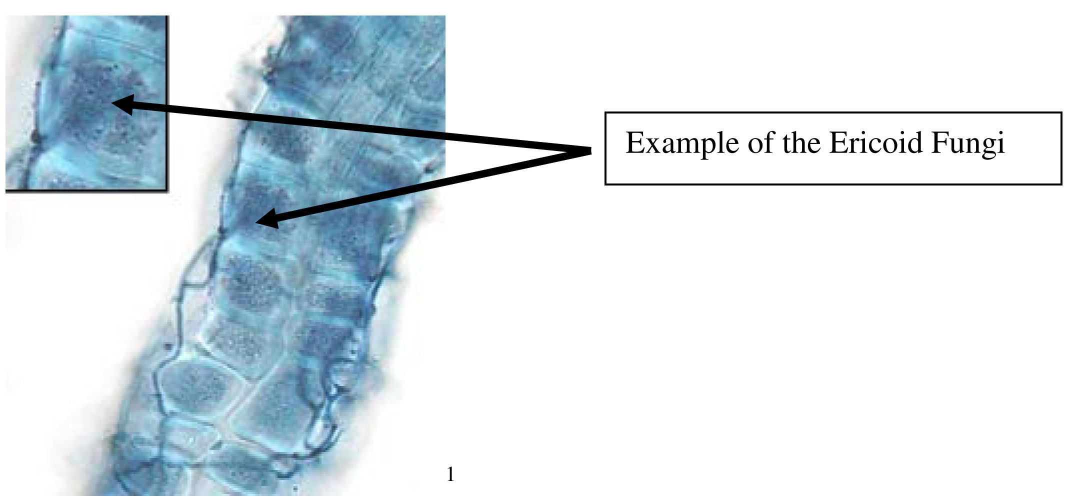
We predicted that the cause of low levels of pH and high levels of iron were due to the high density of rhododendron located in site three. After taking samples and performing multiple rounds of chemical testing we found that our hypothesis was incorrect. According to graph 1.1, even though levels of pH are very low and the iron is abnormally high, there is still the normal relationship between them. The normal relationship is that as the pH levels go down, the iron levels go up.

The abundance of iron in the soil is controlled by iron oxide and with the acidity of the soil, the oxide is being taken away which leaves only the iron in the soil. After finding that our hypothesis was incorrect that led us to more research which led us to find that there is a significant connection between pH and iron in soil.

The less pH you have the more hydrogen ions there are in the soil, the higher the pH the more hydroxides. The hydroxides attach to the iron and form Fe +3 (OH-). Since the pH is lower there are more hydrogen ions floating therefore they attract the hydroxides, so that leaves more Ferric iron alone in the soil. It leaves for Ferric iron in the soil because instead of the hydroxides attaching to the iron to make Fe +3 (OH-) they attach to the hydrogen to make water molecules.

Rhododendrons, though, are known to live in soil that has very high levels of iron and low levels of pH. (Clemson, 1999) According to our data the density of the rhododendron does not affect the levels of iron and pH. If it is not the density then is has to be something coming from the rhododendron. Therefore, even though the density of the rhododendron is not affecting the abnormally high levels, something is.

There is a fungus that lives within the cell of the hair root of the rhododendron. This fungus is believed to be the reason for the high levels of iron (Haselwandter, 2003). The fungus lives inside the cell and excretes siderophores, a chemical that fixes the iron into a form that the cell can absorb, which then produces the high levels of iron in the soil (Haselwandter, 2003) Therefore, the high levels of iron are produced from the siderophores rather then the rhododendron itself. If the fungus wasn't there in the root then it would not be giving off the siderophores into the root but into the soil because the fungus live inside the root and not in the soil, we could not take any out the soil. Then, the levels of iron and pH would be at a more normal rate and still showing the normal relationship that they should show. Logically our next step in research should be to look and really find the fungus within the cell, do testing and such on the hair root of the rhododendron. Some of the testing that could occur would be trying to extract the fungus, or doing testing for levels of iron and pH.



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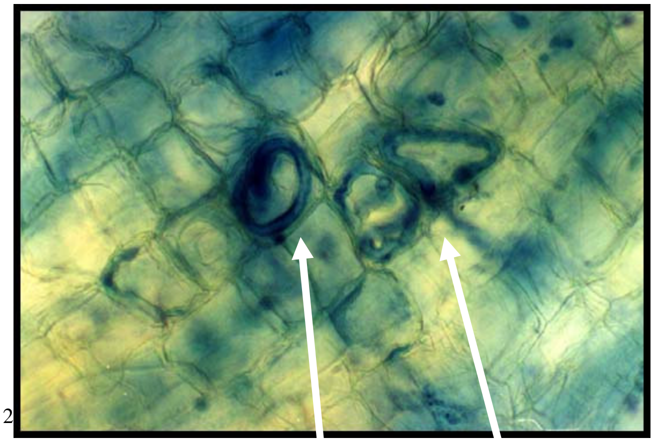
[1] (Available at http://www.ibot.cas.cz/mykosym/mycorrhiza.html)



Second example of the Ericoid Mycorrhizae fu

Bibliography

Haselwandter, K 2003 "Mycorrhizal Siderophores" *Department of Microbiology, University of Innsbruck, Technikerstr*
Online (Available at
http://www.dijon.inra.fr/cost838/scientific_meetings/ljubjana/LjubljanaAbstracts.html)

Smith and Read,1997 "Ericoid Mycorrhizae" *University of Wisonsin*
Online (Available at http://botit.botany.wisc.edu/courses/mpp/EricadMyco.html)

Yarmoshuk,N 1999-2005 " Welcome to the Rhododendron Society of Canada Niagara region" *Niagara, Canada Rhododendron Society of Canada*
(Online) Available http://www.rhodoniagara.org/

Clemson University 2001 "Clemson Extension" *Clemson University South Carolina*
(Online) Available http://hgic.clemson.edu/

State university of New York 2001 "Sunny- ESF" *State University of New York*
(Online) Available http://www.esf.edu/

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[2] (Available at http://sevilleta.unm.edu/research/crossite/carbon/amfungi_copy4.jpg)

Horne, W 2000-2005 “Iron Deficiency Poses Challenge” *College Station eagle* (Online) Available http://www.theeagle.com/homegarden/080902horne.htm;

E.S.S.R.E 2005 "Reserch Summary" General Description of the E.S.S.R.E Survey Sites , https://faculty.rpcs.org/brockda/ESSRE%20Locations.htm

Nay,B (2003)Buffalo Plant Nutrient GuideCedar City*, Utah, USA*
Online (Available at http://www.three-peaks.net/fertilizer.htm)