

Soil Ecology: Erosion and Fungi

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Background

Fungi are eukaryotic microorganisms that can be found in almost any environment. They mostly live in water filled porous soil on or near the roots of plants. (Hooke, n.d) Fungi's role in the soil is to recycle important chemical elements that would otherwise remain locked up in the dead plants (UWA, 2004). Fungi accomplish this through the decomposition of dead plant matter. In addition, the amount of fungi in the soil will impact the soil structure. Without fungi creating a stable soil structure, the soil will be prone to erosion (Britannica, Alexopoulos).

Yeast and mold are two types of fungi which decompose organic material to benefit the producers of the ecosystem. Without them, plants would not get the essential nutrients needed to live. Decomposition occurs when the yeast absorbs nutrients from the organisms (Nature works 2015). Yeast gets food from the organic matter around it by secreting enzymes that break down complex plant cell walls and animal tissue and then absorbing the leftover nutrients (Science clarified 2015). Yeast is a one-celled organism that reproduces asexually by budding. If the living conditions are poor, or if resources are scarce, yeast will produce sexually by fusing with another yeast cell (How stuff works 1998-2015). Yeast is most often seen in environments with little resources, and its presence is a sign that the environment is under stress. Yeast is therefore an important component in the ecosystem.

Mold is another form of fungi that works similar to yeast to decompose organisms in the environment. Mold is a eukaryotic microorganism (Intuitive environment solutions, n.d.) Mold grows in warm, damp, humid environments often in places where leaves and other vegetation are decomposing. (Centers for disease control and prevention 2014). Mold is most often seen in environments that are not stressed and with plentiful resources. It can only grow in areas with water: without moisture, there is no mold (New world encyclopedia 2008). It sexually reproduces using spores that are durable and can survive in most environments (Centers for disease control and prevention 2014).

Different types of fungi can get nutrients or food through different methods. Fungi called saprotrophs, for example, get nutrients from dead organic matter by absorbing their compounds (ck-12, n.d.). In general, fungi eat dead nutrients by releasing an enzyme, such as cellulase, that breaks down the nutrients into less complex carbohydrates so they are able to eat it (Kew, n.d.). Organic materials are broken down from polymers into monomers that can pass through the fungi cell wall. This allows biological molecules to be recycled or to create new cellular material. Some species of fungi such as hunter fungi can eat tiny protozoa and worm-like creatures called nematodes. Other fungi can trap their prey by spraying a sticky substance called glomalin (Microbe World, 2014).

Fungus is made of thin, organic threads called hyphae. Hyphae branch out to form a network of fiber-like material called mycelium. Mycelium's fibrous network maximizes contact with nutrients in the soil by spreading through a larger area of soil. Additionally, the high levels of mycelium lead to better water absorption from the soil. The mycelium also works symbiotically with plant roots such that fungi and plants help each other in taking up nutrients. This is called mycorrhizae, and it occurs when the fungi absorbs water and minerals from the soil and provides them to the plant. The sugars made by the plant then feed the fungi (Campbell, Williamson & Heyden, 2004). Almost all plants have mycorrhizae. There are two types of mycorrhizae: endomycorrhizae and ectomycorrhizae. Fungi that penetrate the plant root are endomycorrhizae. Fungi that surrounds the plant root are ectomycorrhizae (Bio-Organics, 2013). In soil where mycorrhizae are not present, plants are more susceptible to drought and nutrient intolerance.

Fungi is spread through the movement of its spores. Under the right conditions, spores quickly grow into fungal hyphae on the surface of dead plants, starting the decomposition process. Fungi and bacteria work together to further decompose organic material and release carbon, oxygen, nitrogen and phosphorus into soil (Britannica, Alexopoulos). This activity creates nutrient rich topsoil, or humus, that provides plants the nutrition they need to grow and reproduce. This impacts the structure of the soil, as

humus has a negative charge as well as space filling and adhesive properties that bind together different materials (Elsevier, 2004). This leads to bigger clumps of soil, called aggregate, which makes the soil less prone to erosion (My Agriculture Information Bank, 2011).

Erosion takes place when bits of rock or soil are moved from one place to another and the topsoil and humus layer is worn away. Erosion can be caused by wind, water, and ice. Wind erosion carries dust, sand, volcanic ash from one place to another. Wind blowing sand into dunes is an example of wind erosion and when windblown sand cuts across a rock with extreme force, it will wear away the rock over time. Water erosion slowly washes away rock fragments and carries away small bits of nutrient containing soil. The Colorado River and the Grand Canyon show the effects of water erosion. The shorelines cliffs and the caves within the cliffs are examples of the effects of erosion caused by the ocean waters. Ice erosion occurs as glaciers slowly move down a hill picking up soil, sand, and rocks in the process (National Geographic). The North American and north European landscapes show the effects of ice erosion caused by the glaciers (National Geographic). These are all natural effects of wind, water, and ice erosion.

People influence erosion as well. Manmade erosion can be seen when people cut down forests. Topsoil is washed away more easily and this could cause flooding (National Geographic). This could occur at RPCS when rain runs off the building during a storm, more rapidly washing away the earth surrounding the building. In addition, when water is discharged from the building through drainage and plumbing, the water can cause underground erosion that can affect the land on the surface (Clark County, 2013). When the grass is mowed, the soil on downhill slopes around the school can more easily become eroded by wind because the soil's protection has been removed.

We are conducting an experiment to determine how erosion will impact the population of fungus on a hill in soil at Roland Park Country School. We hypothesize that the middle of the hill will

have the lowest population density of fungi, and the bottom of the hill will have the highest population density of fungi. We determined this hypothesis because we suspected the topsoil would be pushed from the middle of the hill to the bottom of the hill. The rich topsoil from the middle of the hill would end up at the bottom of the hill. Therefore, there will be a lower population density of fungi in the middle of the hill, and a higher population density of fungi in the bottom of the hill. The top of the hill is the negative control because we believe the erosion at the top of the hill will be minimal.

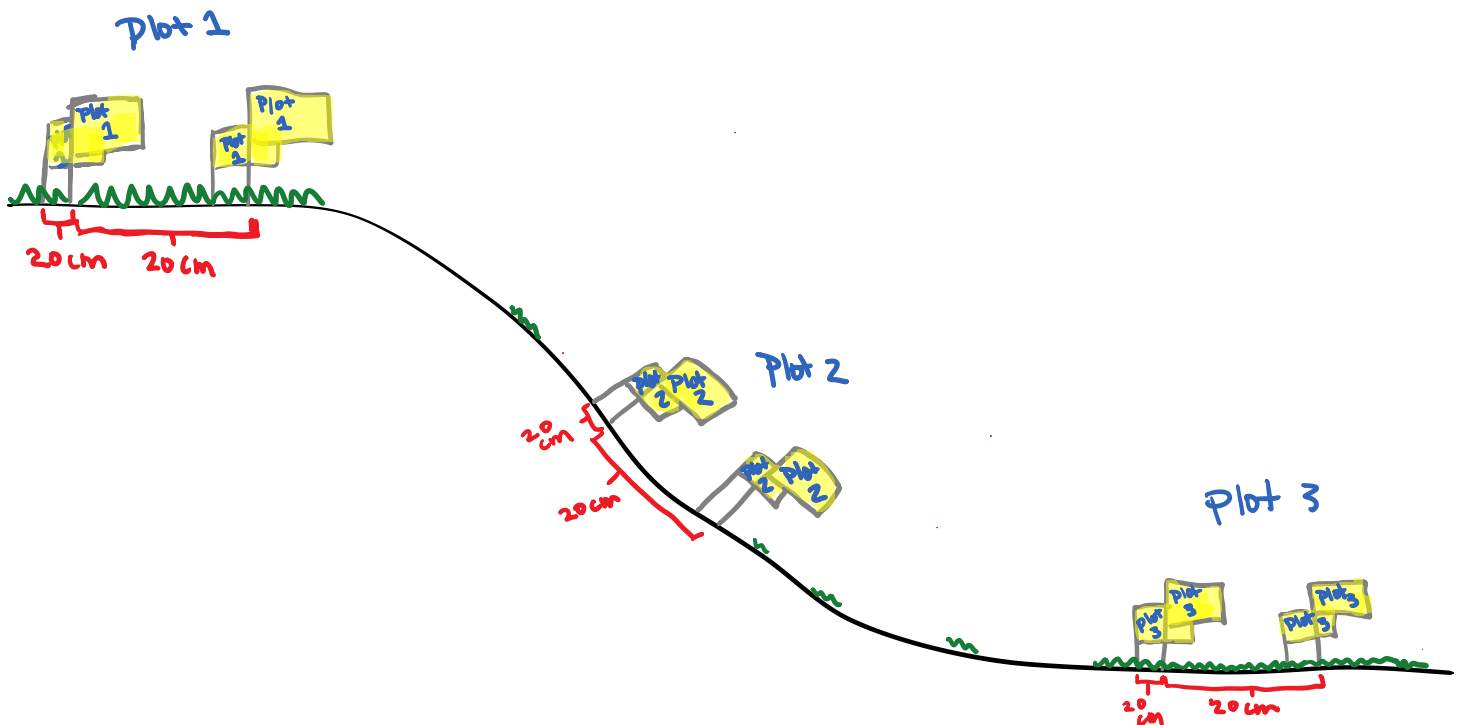
Lab Outline

- I. Problem: How does erosion change the population density of fungi in the soil?
- II. Hypothesis: The middle of the hill will have the lowest population density of fungi, and the bottom of the hill will have the highest population density of fungi.
- III. Procedure:
 - A. Independent Variable: Soil samples extracted from bottom and middle part of the hill (plots 3 & 2) which are expected to be the most affected by erosion.
 - B. Dependent Variable: Population density of Fungi of 1cc soil
 - C. Negative Control: Soil from top of the hill (plot 1). This is expected to be the least affected by erosion.
 - D. Controlled Variables: Time of day, location of soil samples, amount of soil extracted, size of plot, amount of time fungi plates grow, amount of water in dilutions, amount of soil in dilution, 100 μ l dilution on fungi plates, amount of sterile water in 10^0 tube, amount of sterile water in 10^{-1} tube, amount of sterile water in 10^{-2} tube, 1cc of soil and sterile water mixture, fungi plates from the brand 3M Petrifilmtm.
 - E. Step by Step:
 1. Mark square area 20x20cm with 4 flags labeled "plot 1" at coordinates (N: 39° 21.422 W: 076° 38.162). See figure 1.
 2. Mark square area 20x20cm with 4 flags labeled "plot 2" at coordinates (N: 39° 21.427 W: 076° 38.162). See figure 1.
 3. Mark square area 20x20cm with 4 flags labeled "plot 3" at coordinates (N: 39° 21.428 W: 076° 38.164). See figure 1.
 4. Place soil core sampler into the plot 1 at the top of the hill. Put soil core sampler into the ground and hammer (if needed) to 15 cm underground.
 5. Twist soil sampler clockwise to extract soil. Lift soil core sampler out of ground and put soil into plastic bag labeled "plot 1 trial 1".
 6. Move to the plot 2 and repeat steps 4-5 and label plastic bag "plot 2 trial 1".
 7. Move to the plot 3 and repeat steps 4-5 and label plastic bag "plot 3 trial 1".
 8. Repeat steps 4-7 two more times to extract trial 2 and trial 3. Label the plastic bags by plot and trial number.
 9. All trial 1 samples must be diluted on the same day at the same time (this applies to all trials.) Take all three plastic bag soil samples and complete dilution process in steps 10 through 20.
 10. Use a clean new transfer pipette to add 10 ml of sterile water to a 15 ml culture tube. Label the tube " 10^0 plot 1 trial 1". Add 1cc of plot 1 trial 1 soil, using the 1-cc scoop, into this tube and shake vigorously.
 11. Wash 1-cc scoop.
 12. Use the same pipette from step 11 and add 9 ml of sterile water to two 15 ml culture tubes. Label one tube " 10^{-1} plot 1 trial 1", and the other " 10^{-2} trial 1 plot 1". Place these tubes next to " 10^0 plot 1 trial 1" tube with the plot 1 soil.
 13. Using a new clean pipette, remove 1 ml of the soil/water mixture from " 10^0 plot 1 trial 1" tube and place into " 10^{-1} plot 1 trial 1" tube from the soil from trial 1.
 14. Cap and shake vigorously.
 15. Using the same pipette in step 13, remove 1 ml of the soil/water mixture from the " 10^{-1} plot 1 trail 1" tube and place into the " 10^{-2} plot 1 trail 1" tube.

16. Cap and shake vigorously
17. Plate 100 μl samples from all three tubes (dilutions 10^0 , 10^{-1} , and 10^{-2}) onto their own separate, labeled 3M Petrifilm™ yeast and mold count plates containing nutrient agar
18. Allow yeast and mold colonies to grow for 72 hours.
19. Examine each of the plates for yeast and mold colonies. Look at the 10^{-2} plate for yeast and mold colony. If no colonies are found move to the 10^{-1} plate and look for the colony that was not found. If that colony is still not found move to the 10^0 plate. Yeast colonies are sharp dots and mold colonies are fuzzy circle that can differ in size. Choose the plate with the fewest colonies to make your estimates of the number of fungi in the original 1 cc soil sample using the following formula.

$$\# \text{ Microbes in 1 cc of soil} = \# \text{ colonies of sheet} \times 10^2 \times 10^{\text{dilution \# at which these colonies were found}}$$
20. Record the amount of yeast and mold colonies into data table.
21. Repeat steps 9-20 for trials 2 and 3 samples.

figure 1



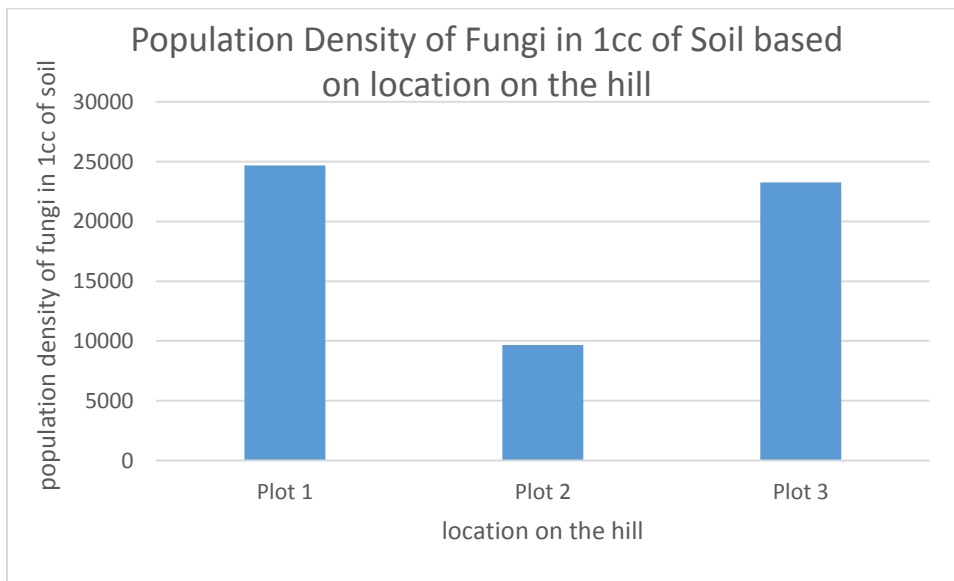
Data/Observations

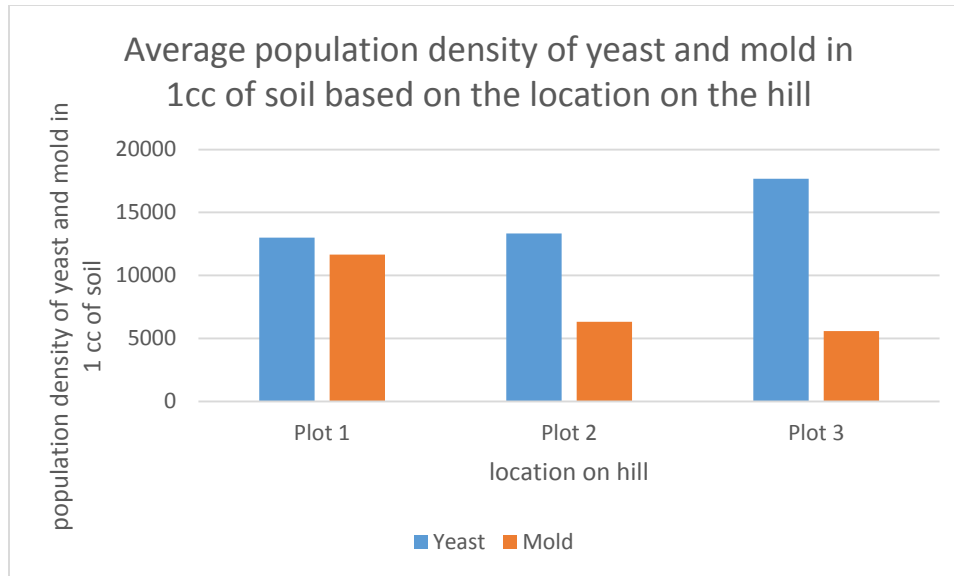
Population density of fungi in 1cc of soil based on location on the hill

	Sample	Yeast colonies in 1 cc of soil	Mold colonies in 1cc of soil	Total fungi 1cc of soil
Trial 1	Plot 1	3000	5000	8000
	Plot 2	10000	2000	12000
	Plot 3	3000	2000	5000
Trial 2	Plot 1	30000	20000	50000
	Plot 2	20000	10000	30000
	Plot 3	10000	800	10800
Trial 3	Plot 1	6000	10000	16000
	Plot 2	10000	7000	17000
	Plot 3	40000	14000	54000

Averages population of fungi, mold, and yeast in 1cc of soil based on location on the hill

	Plot 1	Plot 2	Plot 3
Total number of fungi colonies in 1cc of soil	24666.6667	9666.6667	23266.6667
Yeast in 1cc of soil	13000	13333.333	17666.666
Mold in 1cc of soil	11666.6666	6333.333	5600





Conclusion

The population density of fungi drastically decreased in the eroded soil. Specifically, the total average population of fungi at the top of the hill is 24,666 colonies in 1cc of soil. The total average population of fungi at the bottom of the hill is 23,266 colonies in 1cc of soil. In other words, the total average population of fungus decreased by 15,000 fungi from the 1st plot (top of the hill) to the 2nd plot (middle of the hill). Thus, the hypothesis was partially supported because the overall population decreased in the eroded area. However, the population density of fungi was highest in the first plot at the top of the hill, rather than in the third plot, at the bottom of the hill, as hypothesized. The hypothesis was that the third plot would have the highest population density average, because we believed the topsoil, and the fungi in the topsoil, from the eroded area would run to the bottom of the hill.

The experiment proved that the bottom of the hill is also affected by erosion, in that the mold population went down. However, the population of yeast did not follow this pattern. In the eroded soil, the population of yeast was about the same as in the non-eroded soil. At the top of the hill, the total average of yeast in 1cc of soil is 13,000 colonies. In the middle of the hill, the total average population of yeast in 1cc of soil went up to 13,333 colonies. At the bottom of the hill, the total average population of yeast continued to go up to 17,666 colonies in 1cc of soil. What decreased the second plot's total fungus population was its lack of mold. The average population in the first plot, at the top of the hill, was 11,666 mold in 1cc of soil. In the second plot, at the middle of the hill, the average population went down to 6,333 mold in 1cc of soil. The average population of mold decreased even more to the bottom of the hill, with 5,600 colonies in 1cc of soil.

The data suggests that yeast and mold are affected differently by erosion. Yeast reproduces in normal conditions and also stressed conditions. If anything, yeast can thrive in compromised environments. Mold can only grow in healthy soil with moisture. Ultimately, the hypothesis was not supported because the highest population density of fungi was not at the bottom of the hill, but at the top of the hill.

In future trials, this experiment should be practiced on a larger scale. Researchers should conduct more trials and collect more data. The more data collected, the more definitive the results will be. Researchers should do the experiment over a longer time span, closer to a year. They could test to see the change in fungi population density in all kinds of weather during every season. Further, future experiments could be conducted to test different types of erosion to see how that affects the population of fungi. Researchers could test soil in areas with dust, sand, or even volcanic ash, and test with the dilution process to see how wind erosion affects the fungi population density. Researchers could set up experiments in colder areas where glaciers are a part of the landscape and test the soil using the dilution process to see if ice erosion decreases to population density of fungi. Finally, future researchers could test eroded soil near a water source to see if the population density increases or decreases with water erosion. Different types of erosion such as wind, ice, and water might affect the fungi population density. Future researchers should explore all these possibilities.

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