The Effect of the Depth of Soil on the Rate of Decomposition of a Banana Peel

Environmental Issue: Desertification

Our planet is being increasingly plagued by the effects of desertification as human activities, climate change, and other factors threaten soil quality. Desertification refers to the process of land degradation by which once fertile land becomes arid and the soil becomes similar to that of a desert biome.[1] A few chief causes of this phenomenon include overgrazing, industrialization, deforestation, unsustainable agricultural practices, and climate change.[2] As desertification occurs, topsoil is stripped away until the land is no longer fertile, leaving behind a barren desert. It has been estimated that in the last 150 years, half of the earth's topsoil has disappeared.[3] As urbanization increases and climate change becomes more severe, this problem only develops at faster rates.

The negative effects of desertification are widespread and dangerous as it makes agriculture almost impossible. The lack of rich topsoil means that plants are not able to survive, which can lead to a decrease in biodiversity as well as to world hunger as crops are not able to be grown for consumption. Additionally, flooding becomes a larger issue as there is no plant life to absorb and disperse waters, and this can lead to poor water quality as well.[4] These effects are decreasing the quality of life for millions of people and resulting in environmental damage that is very difficult to reverse.

In the words of Luc Gnacadja, former Executive Secretary of the United Nations Convention to Combat Desertification, desertification is "the greatest environmental challenge of our time" and is "a threat to global wellbeing".[5] The United Nations Environmental Program estimates that measures to prevent desertification will cost about 4.5 billion dollars each year for the next twenty years.[6] Currently, some of the most viable solutions to desertification include more policies regarding ethical farming and land use. Greater education and advances in technology

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[1] "Causes, Effects and Solutions of Desertification." *Conserve Energy Future*, 4 Jan. 2017, www.conserve-energy-future.com/causes-effects-solutions-of-desertification.php.

[2] "Desertification and Drought." *Together Against Trafficking in Human Beings*, 11 Jan. 2019, ec.europa.eu/jrc/en/research-topic/desertification-and-drought.

[3] "Soil Erosion and Degradation." *WWF*, World Wildlife Fund, www.worldwildlife.org/threats/soil-erosion-and-degradation.

[4] "Causes, Effects and Solutions of Desertification." *Conserve Energy Future*, 4 Jan. 2017, www.conserve-energy-future.com/causes-effects-solutions-of-desertification.php.

[5] Carrington, Damian. "Desertification Is Greatest Threat to Planet, Expert Warns." *The Guardian*, Guardian News and Media, 16 Dec. 2010, www.theguardian.com/environment/2010/dec/16/desertification-climate-change.

[6] "Desertification." *Young People's Trust For the Environment*, 11 Sept. 2014, ypte.org.uk/factsheets/desertification/how-big-a-problem-is-desertification.

have also been cited as possible prevention methods.[7] At this point, there is no clear answer that could completely solve this crisis, but steps are being taken to try and combat it.

Research Question:
How does the depth of soil affect the rate at which a banana peel decomposes?

Hypothesis:
I hypothesize that as soil depth increases, the rate at which the banana peel decomposes will decrease. This is because as soil depth increases, the soil becomes less fertile as microorganisms can no longer be supported due to a lack of nutrients and sunlight. The rate of decomposition of materials in soil is very closely tied in with soil fertility as the factors that affect decomposition are: chemical composition, environmental conditions, creatures/animals in the soil, and microorganisms.[8] Thus, deeper, less fertile soil should cause the rate of decomposition of organic materials to slow.

Purpose:
The purpose of this investigation is to determine the severity of the problem of desertification in order to establish how many resources should be allocated to preventing it. There are many environmental issues threatening our world right now, including climate change, deforestation, pollution, and much more. However, there is a limited supply of resources, namely time and money, that can be spent trying to resolve each of these issues. My findings will prove the difference in fertility among soil of varying depths. If there is a large disparity between the fertility of the topsoil and soil from deeper in the ground, it will be evident that desertification is one of the more pressing problems and that more resources should be spent combating it. This is because a large disparity will indicate that we will not be able to use the soil left behind after desertification for activities such as agriculture since it will not be fertile enough to sustain life effectively. If there is not a significant disparity, it can be concluded that the soil will still be somewhat fertile after it desertifies, and that while this issue is important, it is not something that should occupy a majority of our resources.

[7] "Causes, Effects and Solutions of Desertification." *Conserve Energy Future*, 4 Jan. 2017, www.conserve-energy-future.com/causes-effects-solutions-of-desertification.php.
[8] Singh, J. S., and S. R. Gupta. "Plant Decomposition and Soil Respiration in Terrestrial Ecosystems." Botanical Review, vol. 43, no. 4, 1977, pp. 449–528. JSTOR, JSTOR, www.jstor.org/stable/4353928.

Experimental Variables:

Type of Variable	Variable	Equipment or Method of Control	Units	Justification
Independent	Depth of soil	Using soil harvested from 0” deep, 5” deep, and 10” deep	Inches	To test the difference in the rate of decomposition in soils that come from varying depths in the ground.
Dependent	Rate of decomposition	Digital scale	Grams	To obtain an accurate measure of mass to two decimal points.
Controlled	Type of soil	The soil will be harvested from the same spot, just at varying depths.		Decomposition is faster in certain types of soil due to differences in the amount and types of microorganisms that live in the soil.
	Type of banana peel	The peels will be harvested from the same bunch of bananas.		Different types of banana peels may have different rates of decomposition due to differences in composition, such as the thickness and pH of the peels.
	Room conditions	All soil samples will be kept in the same room in the same area at all times so that temperature, exposure to light, humidity, etc. are kept constant.		Decomposition rates may vary as a result of light available, humidity, and temperature.

Materials List:

1. Gardening gloves
2. Small shovel
3. Tape Measure
4. 5 groups of about 1 dm^3 of soil from the top 2 inches of the ground
5. 5 groups of about 1 dm^3 of soil from 5 inches deep into the ground
6. 5 groups of about 1 dm^3 of soil from 10 inches deep into the ground
7. 5 ripe bananas (from the same bunch)
8. 15 small pots (with a volume of about 1 dm^3)
9. Digital balance

Procedure:

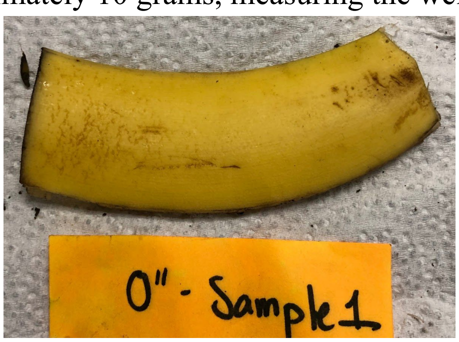
Harvesting Soil

1. Put on gardening gloves.
2. Find a fertile area to harvest the soil from. This is any place that plants are growing and life is supported. Make sure that you have permission to dig there.
3. Harvest approximately 1 dm^3 grams of soil from the top 2 inches of the soil, placing it in a clean, waterproof, sealed container.
    a. 1 dm^3 of soil will be enough to fill a small pot and adequately cover the banana peel so that it will be able to decompose.
    b. 
4. Using the same hole, dig until it is 5 inches deep (using a tape measure to be sure of the depth). Then, harvest approximately 1 dm^3 of soil and place it in a clean, waterproof, sealed container.
    a. Digging to this depth will ensure that soil is gathered from a different horizon.[9]
    b. 

[9] "Soil Horizons." *Soils 4 Teachers*, www.soils4teachers.org/soil-horizons.

5. Using the same hole, dig until it is 10 inches deep (using a tape measure to be sure of the depth). Then, harvest approximately 1 dm^3 of soil and place it in a clean, waterproof, sealed container.
    a. Digging to this depth will ensure that soil is gathered from a different horizon.
    b. 
6. Repeat steps 3-5 four more times, using different patches of soil in the same general area each time.
    a. Five repeats of this experiment will be enough data to reach a conclusion with the assurance that any conclusions drawn are not based on anomalous results.
    b. Using soil from the same area will ensure that the soil is all the same type and of similar composition.
7. Put each group of 1 dm^3 into small pots, labeling each pot with the depth and hole that the soil came from.

Preparing the Banana Peel

1. Peel 5 ripe bananas from the same bunch.
    a. Using bananas from the same bunch will ensure that the peels are of similar composition.
    b. Banana peels are being used to measure the rate of decomposition as they are easily accessible, easy to work with, and have a relatively short decomposition time.
2. Using caution, use a knife to cut a section off of one of the banana peels that is approximately 10 grams, measuring the weight on a digital balance.
    a. 

3. Repeat step 2 fourteen more times so that there is one piece of banana peel for each pot of soil.
4. Place each section into one of the pots of soil, covering them with about 1 inch of soil.
    a. Covering the banana peels with a small amount of soil will ensure that the microorganisms can reach all of it, speeding the decomposition process.

Monitoring the experiment

1. Leave the 15 pots of soil and banana peel in a safe, dry location together.
    a. I put all of the pots together in a room where there would be constant supervision to ensure that there would be no interference with the experiment. This room was constantly being kept at a comfortable, mild temperature and was sheltered from elements such as rain and wind.
2. Measure the progress of the decomposition by:
    a. Carefully removing the banana peels from the soil samples and use a spoon to remove any soil sticking to the peel, being careful not to remove any banana material. Then, weigh them on a digital balance and record their mass.
        i. This will be used to measure how much mass is lost as a result of decomposition.
    b. Taking pictures of the progress.
    c. Returning the peels to their respective pots and covering them with 2 inches of soil.
3. Perform step 2 at least four times over a period of two weeks, recording data for all 15 pots of soil at the same time.
    a. Recording the data for all of the pots at the same time will ensure that they all had the same amount of time to decompose and therefore their results can be compared.
    b. Recording data at least four times will ensure that there are enough data points to draw a conclusion off of and to ensure that nothing unexpected occurred during the experiment.
    c. The experiment will span for two weeks because that is enough time for the banana peel to decompose significantly.[10]

Safety/Ethical Precautions:

1. Check city guidelines to ensure that the area the dirt is being harvested from is not protected by any laws or regulations. Make sure that digging will not violate any cultural boundaries and get any necessary permits.
2. Use gloves when handling soil in order to prevent the spread of potentially harmful microorganisms. Wash hands before and after each interaction with the soil and other experiment materials.
3. Exercise caution when handling the shovel to ensure that no injuries are sustained.
4. Be cognizant of knife safety when dividing the banana peel.

[10] "Material Decomposition." *Save On Energy*, www.saveonenergy.com/material-decomposition/.

Results:

Table 1 - Mass of Banana Peels Decomposing in Soil from Varying Depths over Time

		Day of Experiment			
		1	**3**	**8**	**14**
Soil Depth (inches)	**Sample**	**Mass of Banana Peels (grams) ($\pm$0.01 g)**			
0	**1**	9.97	8.99	3.84	1.27
0	**2**	9.96	9.47	4.60	1.58
0	**3**	9.87	8.59	2.79	0.97
0	**4**	9.98	8.76	4.09	1.38
0	**5**	9.64	8.82	5.29	1.97
5	**1**	9.77	8.65	4.64	2.07
5	**2**	9.73	8.54	2.79	1.88
5	**3**	9.79	8.13	2.66	1.68
5	**4**	9.84	9.55	4.70	2.12
5	**5**	9.98	9.18	3.54	2.03
10	**1**	9.94	8.88	4.15	2.14
10	**2**	9.51	9.06	4.83	2.15
10	**3**	9.32	7.94	3.07	1.77
10	**4**	9.34	7.37	2.76	1.93
10	**5**	9.22	7.42	2.34	1.63

Table 2 - Percent of Mass Remaining and Mass Loss of Banana Peels Decomposing in Soil

Soil Depth (inches)	Sample	Change in Mass (grams) (±0.02 g)	Mass Remaining (%) (±0.1%)	Average Mass Remaining (%) (±0.1%)	Mass Loss (%) (±0.1%)	Average Mass Loss (%) (±0.1%)
0	**1**	8.70	12.7	14.5	87.3	85.5
0	**2**	8.38	15.9		84.1	
0	**3**	8.90	9.8		90.2	
0	**4**	8.59	13.8		86.2	
0	**5**	7.67	20.4		79.6	
5	**1**	7.70	21.2	19.9	78.8	80.1
5	**2**	7.85	19.3		80.7	
5	**3**	8.11	17.2		82.8	
5	**4**	7.72	21.6		78.4	
5	**5**	7.95	20.3		79.7	
10	**1**	7.80	21.5	20.3	78.5	79.7
10	**2**	7.36	22.6		77.4	
10	**3**	7.55	19.0		81.0	
10	**4**	7.41	20.7		79.3	
10	**5**	7.59	17.7		82.3	

Sample Calculation:

Soil Depth: 0 Sample: 1

Start Mass: 9.97 grams

End Mass: 1.27 grams

Change in Mass = Start Mass - End Mass = 9.97 - 1.27 = 8.70 grams

Mass Remaining = $\frac{End\ Mass}{Start\ Mass}(100) = \frac{1.27}{9.97}(100) \approx 12.7\%$

Mass Loss = 100 - Percent of Remaining Mass = 100 - 12.7 = 87.3%

Sample Uncertainty Calculation:

Table 3 - Propagation of uncertainties for the calculation of the percent of mass remaining of Soil Depth 0 Sample 1

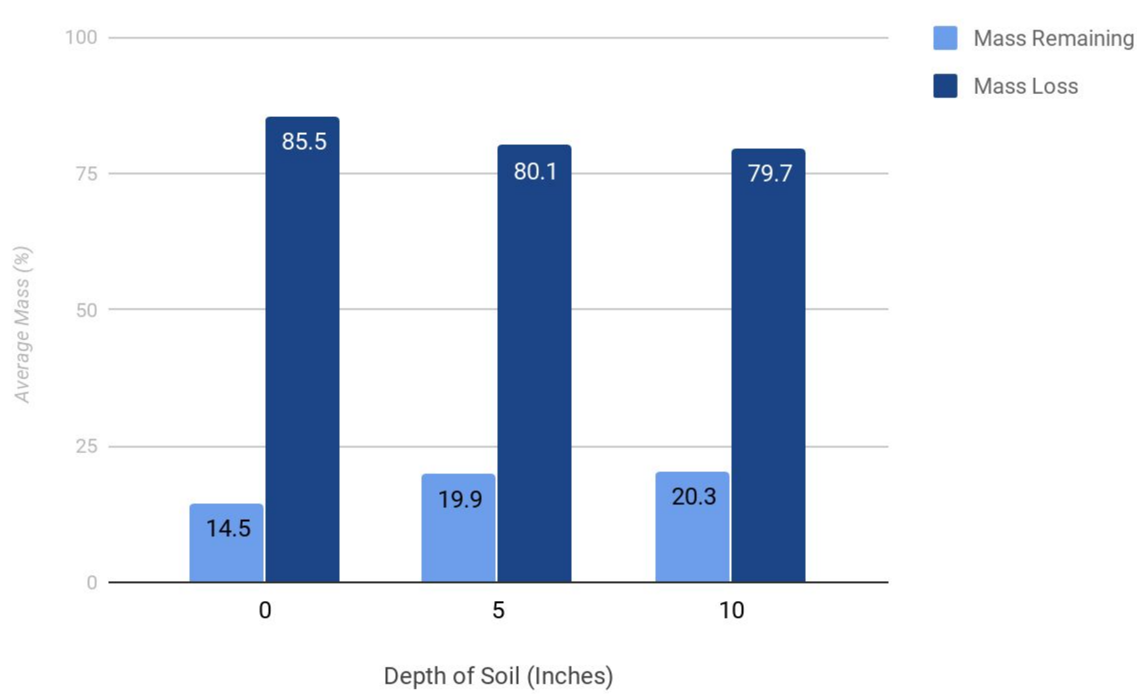
	Measurement	Absolute Uncertainty	Relative Uncertainty (%)
Start Mass (g)	9.97	0.01	0.10
End Mass (g)	1.27	0.01	0.79

Relative Uncertainty of Mass Remaining (%) = Relative Uncertainty of Start Mass (%) + Relative Uncertainty of End Mass (%) = 0.10 + 0.79 = 0.89%

Absolute Uncertainty of Mass Remaining = (Relative Uncertainty of Mass Remaining)(Measurement) = 0.0089(12.7) = 0.11 $\approx$ 0.1

Note: While the absolute uncertainty of mass remaining varies for each soil depth and sample, all of the uncertainties round to ± 0.1*. Therefore, I included* ± 0.1 *as the absolute uncertainty in the heading of the data table because it applies to every sample.*

Chart 1 - Change in Mass of Banana Peels Decomposing In Soils from Different Depths



As the depth that the soil was harvested from increased, the average mass remaining increased and the average mass loss decreased.

Conclusion:
It is evident that as the rate of decomposition increased, so did the depth from which the soil was harvested. At the end of the experiment, the banana peels that were decomposing in soil from the top two inches of the ground lost an additional 5.8% mass on average than those decomposing in soil from ten inches deep and an additional 5.4% compared to the peels decomposing in soil from five inches deep. This data indicates that there is a relatively significant difference in fertility between topsoil and soil from five and ten inches deep in the ground. It also seems to suggest that the fertility of soil from five inches deep is very similar to that of soil from ten inches deep; there was only a difference of 0.4% in the average mass loss of bananas decomposing at these depths. Of course, this data only accounts for differences in fertility for one soil type and therefore cannot be used to make universal judgments.

These results indicate that while there is a measurable difference in the fertility of soil from different depths, this difference is not extreme. The banana peels decomposing in soil from ten inches deep still lost almost 80% of their mass on average, which indicates that this soil is still fertile enough to perform this function. Thus, I can conclude that while desertification is an alarming issue, it may not be one that is the most urgent right now since soil from below the surface of the ground is still relatively fertile.

Evaluation:
In conducting my investigation, I was able to identify several successes as well as potential areas for improvement. One area of success was in the sample size of five samples from each soil depth. This allowed me to ensure that my conclusions were not based on outliers, but rather averages of an appropriate amount of data. Additionally, using mass as a measure of decomposition was successful in that it was an easy quantitative way to track the development of my experiment. The mass changed as expected and this data was useful in determining the answer to my research question.

A significant area for improvement was the method of cleaning the banana peels of soil before weighing them. I chose to use a spoon and paper towel to gently scrape off all of the dirt that I could while trying not to remove any mass from the actual peel. However, this was not entirely effective because there was no way for me to ensure that I was able to get all of the dirt off and none of the banana. Any amount of dirt left on the banana could have made the mass appear much more than it actually was. Additionally, scraping off parts of the banana could have resulted in a lower mass, making it appear as if the banana decomposed more than it actually did. In future investigations, I might consider leaving the banana in the pot while measuring. Since the weight of the pot and the soil is not changing, any change in the mass would come as a result of the decomposition of the banana peel. This would eliminate the human error in this aspect of the experiment.

Additionally, a weakness in my investigation was using only one soil type. Different soil types have different properties and microorganisms within them; therefore they decompose organic materials differently. Using one soil type in this experiment restricted my conclusion to only applying to this type rather than soil in general. In the future, I could perform several experiments on many different types of soil in order to understand the severity of the effects of desertification more completely.

Application/Solutions:

My results indicate that desertification is not one of the most threatening environmental issues at this time; the disparity in the fertility of soil from different depths was not so significant that as a society we should focus the majority of our resources on it. However, from my background research I know that it is an important issue and that we should certainly be implementing solutions to try to combat and reverse its effects. For this reason, I propose that there should be regulations applied to limit the effects of desertification and protect the fertility of our soils that are easy to implement while still being effective. For example, efforts should be made to prevent soil degradation through proper crop maintenance such as maintaining crop cover year-round and keeping crop stubble in place. While these regulations could produce positive results, it is also possible that they could not be entirely effective because people could choose to not abide by them. Additionally, crop rotation and polyculture could be put into practice to ensure that the soil is not being depleted of nutrients faster than they can be restored.[11] Of course, polyculture is not as efficient as monoculture and therefore cannot feed a massive amount of people quickly. For that reason, this may not be a viable solution for areas that need greater efficiency in agriculture due to a growing population. While there are several drawbacks to these methods, these actions do not require a massive amount of time and money but are still extremely effective in preventing desertification. This way, the majority of our resources can be spent combating different environmental issues that present large threats at the moment, such as climate change. These solutions can be executed at a large or local scale, which encourages whole communities as well as individuals to take actions against desertification.

[11] "Five Ways to Help Stop Desertification of the World." *The Borgen Project*, 21 June 2017, borgenproject.org/stop-desertification/.

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