Factors Affecting Infiltration Rates

Aim: An investigation on how different factors affect the rate of soil infiltration.

Introduction: In the practical experiment several sites will be tested for their infiltration rates. Infiltration is the process of water entering the soil. The rate of infiltration is the maximum velocity at which water enters the soil surface. Different types of soils infiltrate at different rates due to various factors.
Opposing factors will be compared in terms of the infiltration rate. The practical will be carried out at Small Heath Park, these are the activities that will be carried out:

- Select factors to be tested
- Find the location
- Do the experiment
- Record the results
- Produce a write-up

In this write-up I will present each factor along with a picture, results table and an explanation.

Research:

IT source

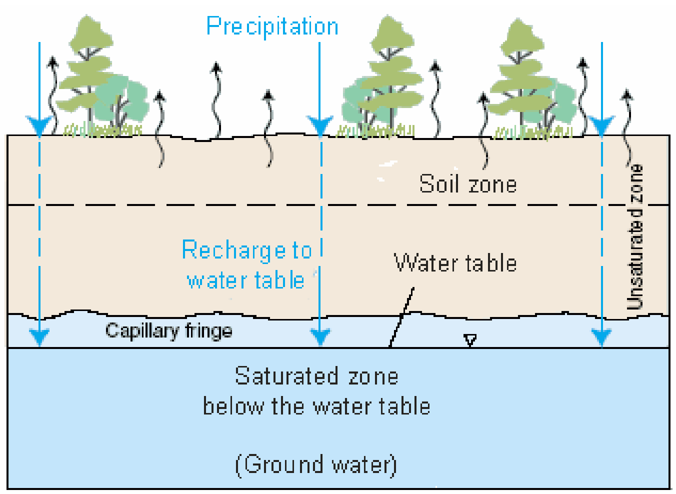
Water infiltrates fast into a dry material and then slows down, as the material becomes wetted. The gravel had the highest i nfiltration rate followed by the sand and the soil was the slowest.

The movement of water through a material depends on the moisture content of the material, the pressure on the water at the surface, and the grain size of the material as well as other fact ors. For this test we see that the infiltration rates slow, as the material becomes wet. We also see that course grain materials, such as gravel, have higher infiltration rates than fine-grained materials, such as soil.

The rate water flows through a saturated material is important in many situations. One is to determine the maximum sustained wastewater discharge rate that a septic tank drain field can handle without pounding up and causing problems. Other uses of the saturated hydraulic conductivity (infiltration rate through a saturated material) is to predict the rate of flow of groundwater towards a well for pumping. It is used to predict the maximum discharge rate that the well can provide.

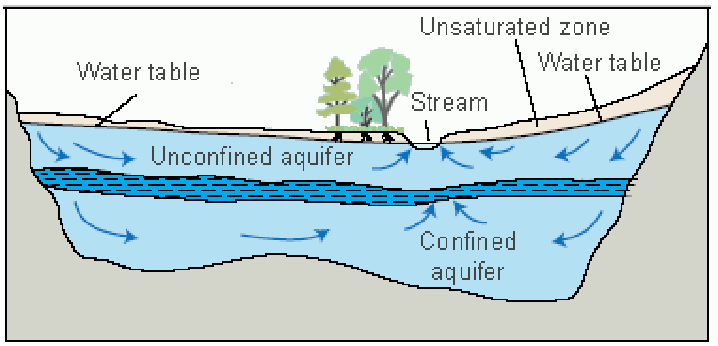
Subsurface water

As precipitation infiltrates into the subsurface soil, it generally forms an unsaturated zone and a saturated zone. In the unsaturated zone, the voids—that is, the spaces between grains of gravel, sand, silt, clay, and cracks within rocks—contain both air and water. Although a lot of water can be present in the unsaturated zone, this water cannot be pumped by wells because it is held too tightly by capillary forces. The upper part of the unsaturated zone is the soil-water zone. The soil zone is crisscrossed by roots, openings left by decayed roots, and animal and worm burrows, which allow the precipitation to infiltrate into the soil zone. Water in the soil is used by plants in life functions and leaf transpiration, but it also can evaporate directly to the atmosphere. Below the unsaturated zone is a saturated zone where water completely fills the voids between rock and soil particles.



Infiltration replenishes aquifers

Natural refilling of deep aquifers is a slow process because ground water moves slowly through the unsaturated zone and the aquifer. The rate of recharge is also an important consideration. It has been estimated, for example, that if the aquifer that underlies the High Plains of Texas and New Mexico—an area of slight precipitation—was emptied, it would take centuries to refill the aquifer at the present small rate of replenishment. In contrast, a shallow aquifer in an area of substantial precipitation such as those in the coastal plain in south Georgia, USA, may be replenished almost immediately.



Artificial recharge gives natural infiltration a push

People all over the world make great use of the water in underground aquifers all over the world. In fact, in some places, they pump water out of the aquifer faster than nature replenishes it. In these cases, the water table, below which the soil is saturated and possibly able to yield enough water that can be pumped to the surface, can be lowered by the excessive pumping. Wells can "go dry" and become useless.

In places where the water table is close to the land surface and where water can move through the aquifer at a high rate, aquifers can be replenished artificially. For example, large volumes of ground water used for air conditioning are returned to aquifers through recharge wells on Long Island, New York. Aquifers may be artificially recharged in two main ways:

- Rapid-infiltration pits: One way is to spread water over the land in pits, furrows, or ditches, or to erect small dams in stream channels to detain and deflect surface runoff, thereby allowing it to infiltrate to the aquifer
- Ground-water injection: The other way is to construct recharge wells and inject water directly into an aquifer

This picture shows rapid infiltration basins (photograph courtesy of Water Conserv II facility, Orlando, Florida) in Orlando, Florida. The water put into these basins recharges the shallow surficial aquifer and is used to irrigate local citrus crop fields.

Research:

Non IT Source

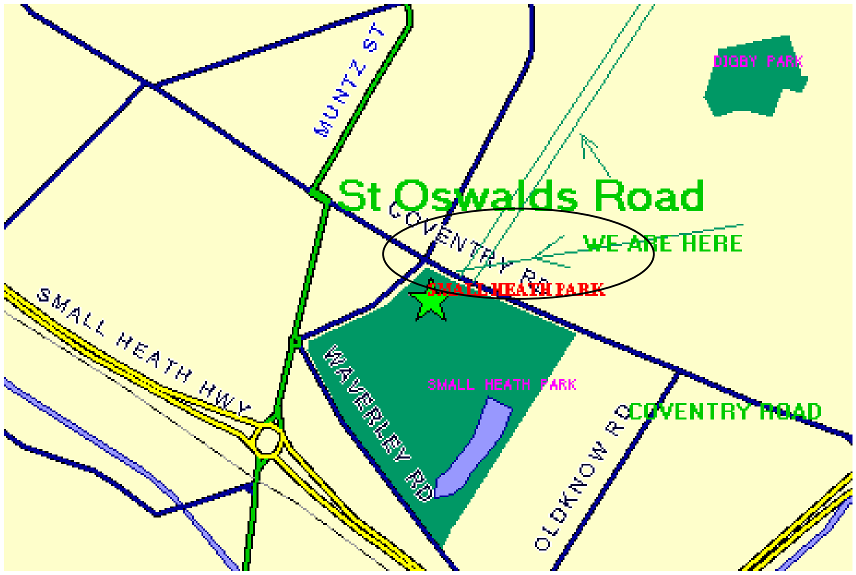
Infiltration and Soil Water Storage

Infiltration refers to the movement of water into the soil layer. The rate of this movement is called the infiltration rate. If rainfall intensity is greater than the infiltration rate, water will accumulate on the surface and runoff will begin.
Movement of water into the soil is controlled by gravity, capillary action, and soil porosity. Of these factors soil porosity is most important. A soil's porosity is controlled by its texture, structure, and organic content. Coarse textured soils have larger pores and fissures than fine-grained soils and therefore allow for more water flow. Pores and fissures found in soils can be made larger through a number of factors that enhance internal soil structure. For example, the burrowing of worms and other organisms and penetration of plant roots can increase the size and number of macro and micro-channels within the soil. The amount of decayed organic matter found at the soil surface can also enhance infiltration. Organic matter is generally more porous than mineral soil particles and can hold much greater quantities of water.

The rate of infiltration normally declines rapidly during the early part of a rainstorm event and reaches a constant value after several hours of rainfall. A number of factors are responsible for this phenomena, including:

(1) The filling of fine soil pores with water reduces capillary forces.
(2) As the soil moistens, clay particles swell and reduce the size of pores.
(3) Raindrop impact breaks up soil clumps, splashing fine particles into pores.

Map of Location (Small Heath Park)



Apparatus:

The apparatus used in the experiment are:

- Infiltration ring
- Stopwatch
- Ruler
- Results table
- Clip board
- Water
- Water container
- Pen/Pencil


Method:

1) I will find the location I need to study e.g. Flat ground
2) I will place the infiltration ring into the ground
3) I will take a photograph/sketch the test area
4) I will pour water into the ring and start timing the test
5) I will record the results into my results table
6) I will repeat this test three times
7) Steps 1-6 are repeated for all factors

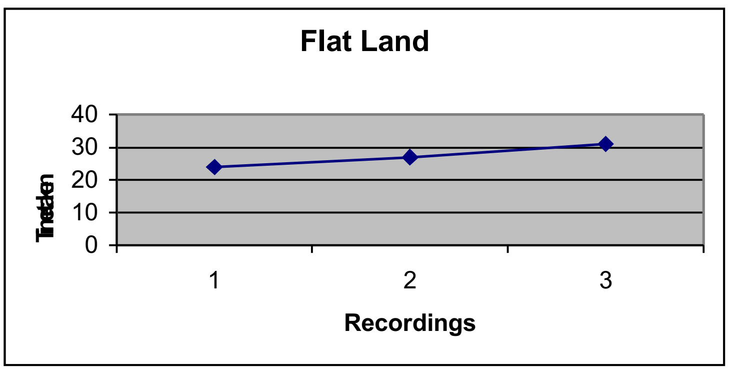
Predictions:

1) Flat Land- Quick infiltration
2) Sloped Land- Slow infiltration
3) Shaded Land- Slow infiltration
4) Unshaded Land- Quick infiltration
5) Near a Tree- Quicker infiltration (Quicker than near a hedge)
6) Near a Hedge- Quick infiltration
7) Muddy Area- Slow infiltration
8) Dry Area- Quick infiltration

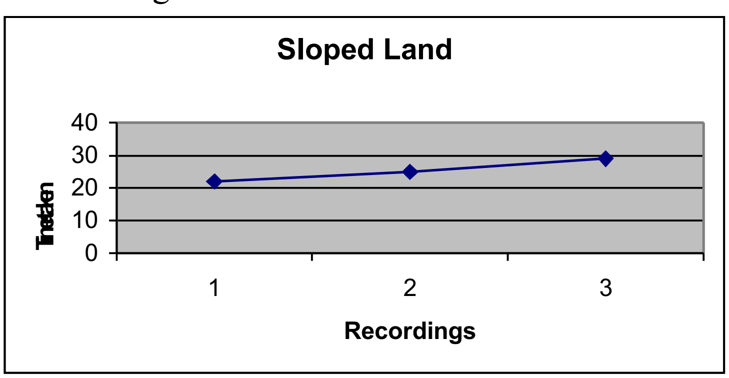
“Flat Land” & “Sloped Land”

Type Of Land	Time 1 (seconds)	Time 2 (seconds)	Time 3 (seconds)	Average Time (seconds)
Flat	24	27	31	27.33
Sloped	22	25	29	25.33

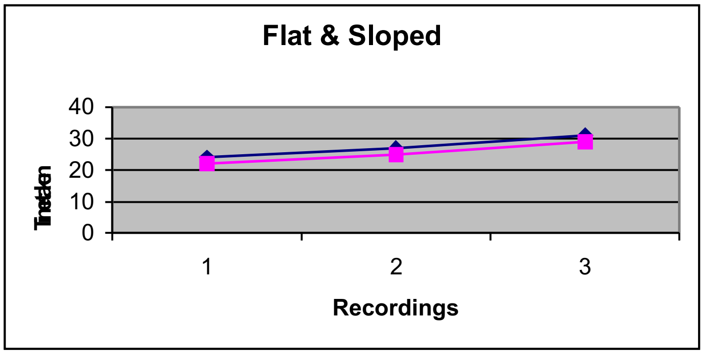
Here are graphs showing the results above:



The time taken greatly increases over the three recordings made. The line shows a positive correlation, which clearly demonstrates an incre asing time for each recording made.



The time taken has a slight increase over the three recordings.
The last recording shows an increase of seven seconds from the first.



Conclusion:

This comparison graph shows that flat land took longer to infiltrate than sloped land.
The flat land is made up of soil, which is in a fixed formation and compact. However the sloped land is made of soil that doesn't have a tight formation. Therefore water is able to infiltrate through easier. A compact surface restricts the entry of water into the soil and tends to result in a small puddle of water. Sloped land isn't straight and flat and therefore water can infiltrate easier.

Quotes

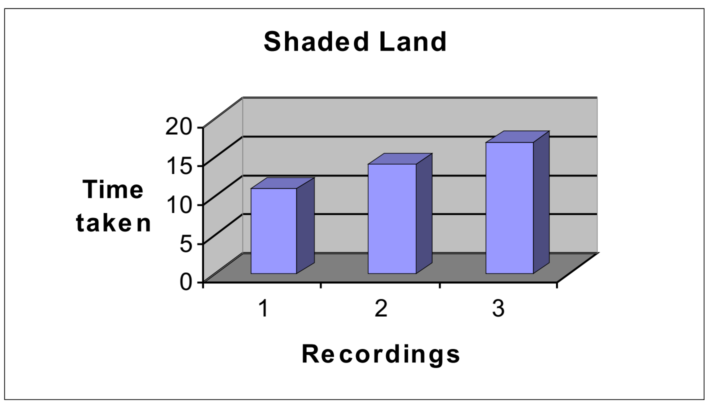
Slope of the land: Water falling on steeply sloped land runs off more quickly and infiltrates less than water falling on flat land.

My earlier prediction is proved wrong as flat land wasn't as quick to infiltrate and sloped land was.

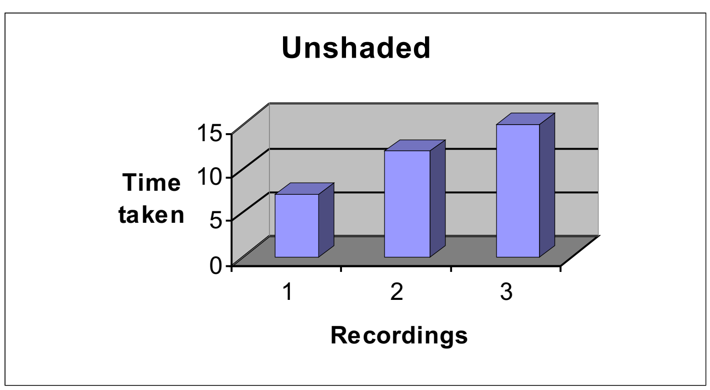
“Shaded Land” & “Unshaded Land”

Type Of Land	Time 1 (seconds)	Time 2 (seconds)	Time 3 (seconds)	Average (seconds)
Shaded	11	14	17	14
Unshaded	7	12	15	11.33

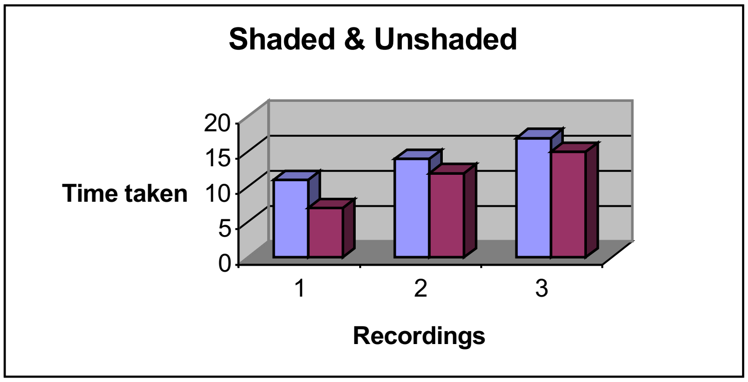
Here are graphs showing the results:



The shaded land never took very long to infiltrate. The graph displays that the repeated trails took longer.



The bar graph above shows that an unshaded area infiltrates very quickly. This is due to exposure to sunlight.



Conclusion:

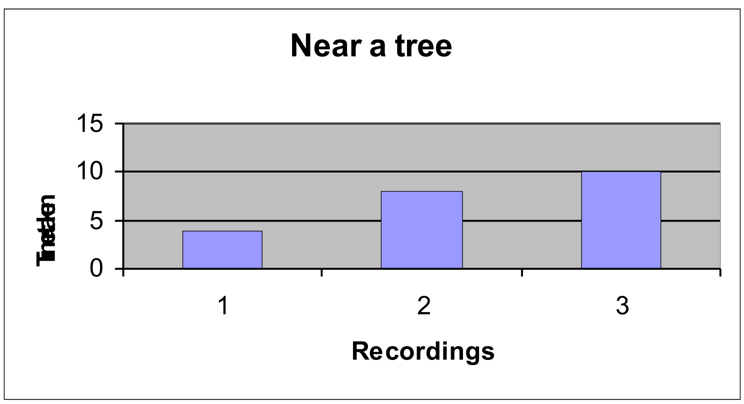
This graph is showing a comparison between the infiltrations of the two factors. The land that had no sunlight on it was slower to infiltrate. Land that has sunlight upon it makes the soil dryer and in need for more water. The heat evaporates the moisture leaving dry soil. This isn't the case when no sunlight is present therefore a longer time is taken for infiltration. The movement of water through a material depends on the moisture content of the material, the pressure on the water at the surface, and the grain size of the material as well as other factors.

My prediction is proved correct in this case as the unshaded area infiltrated quicker. Sunlight on the unshaded area caused faster infiltration, as water was also evaporating. Shaded land was cool and out of sunlight, this resulted in slower infiltration.

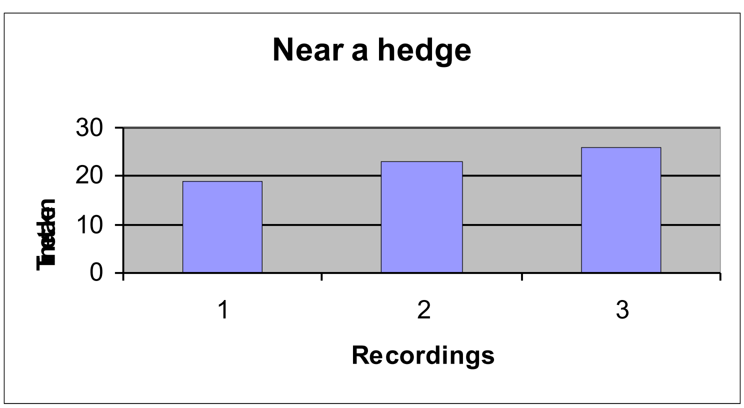
“Near a tree” & “Near a hedge”

Type of Land	Time 1 (seconds)	Time 2 (seconds)	Time 3 (seconds)	Average Time (seconds)
Near a tree	4	8	10	7.33
Near a hedge	19	23	26	22.66

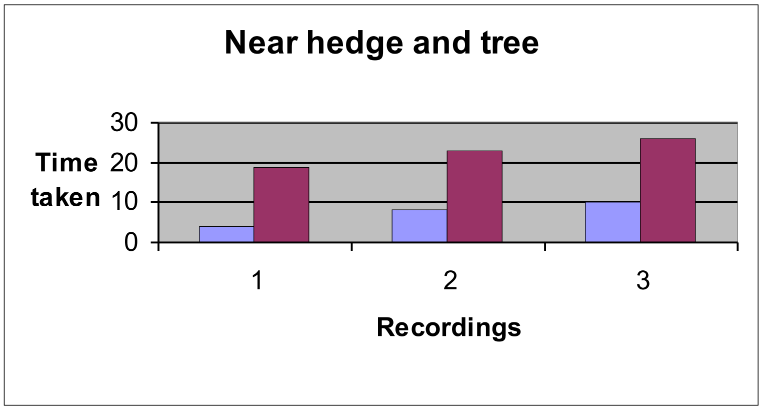
This graph is showing the results in the table:



The graph shows that water is taken in very quickly by soil near a tree. The first recording shows that in 4 seconds the water was infiltrated. It slowed down eventually.



This graph also shows a more rapid rate of infiltration. Near a hedge the infiltration rate is quick but not as quick as near a tree.
The graph below is showing a comparison of the two factors.



Conclusion:

From the graph it is seen that soil near a tree, has infiltrated faster than when near a hedge on all of the three recordings made. The reason for this is that the soil near a tree has roots in them, which absorb a lot of water. As water is taken in by the tree more water can be infiltrated as result. The amount of decayed organic matter found at the soil surface can also enhance infiltration. Organic matter is generally more porous than mineral soil particles and can hold much greater quantities of water.

Quotes:

Land cover: Some land covers have a great impact on infiltration and rainfall runoff. Vegetation can slow the movement of runoff, allowing more time for it to seep into the ground. Impervious surfaces, such as parking lots, roads, and developments, act as a "fast lane" for rainfall - right into storm drains that drain directly into streams. Agriculture and the tillage of land also changes the infiltration patterns of a landscape. Water that, in natural conditions, infiltrated directly into soil now runs off into streams.

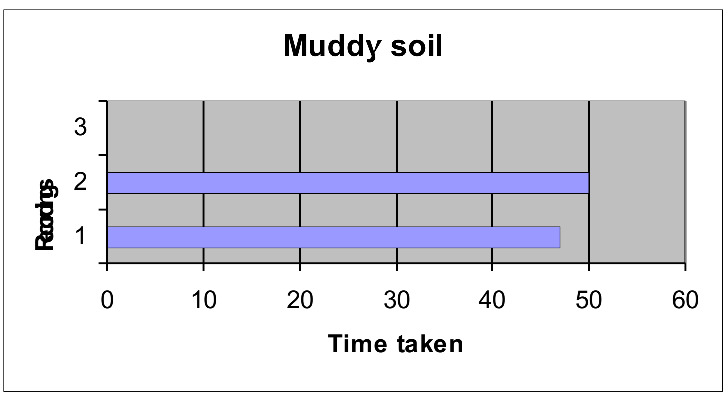
Evapotranspiration: Some infiltration stays near the land surface, which is where plants put down their roots. Plants need this shallow ground water to grow, and, by the process of evapotranspiration, water is moved back into the atmosphere.

This proves my prediction was accurate, as I stated soil near a tree would infiltrate at a quicker rate.

"Muddy soil" & Dry soil"

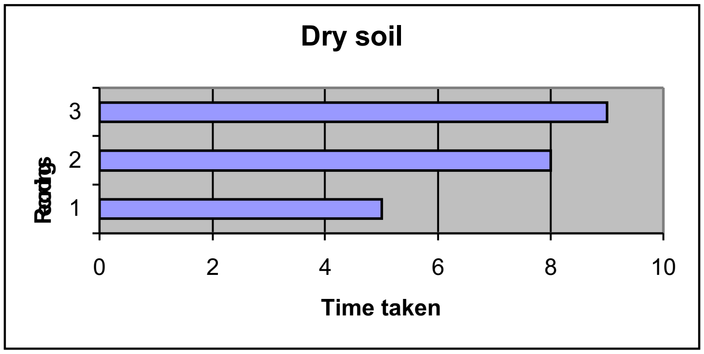
Type of land	Time 1 (seconds)	Time 2 (seconds)	Time 3 (seconds)	Average Time (seconds)
Muddy soil	47	50	No infiltration	48.5
Dry soil	5	8	9	7.33

These are graphs showing the results:

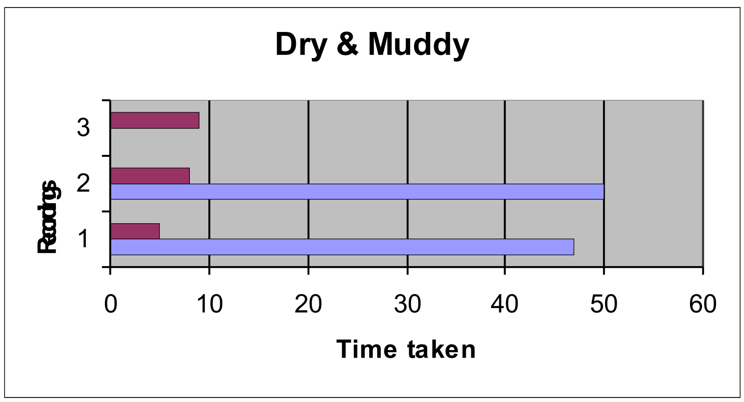


The graph is showing a very slow rate of infiltration. Eventually it got even slower and in the last attempt no water infiltrated. This is due to the soil already being wet. A puddle was left in the land when no more infiltrate.

Infiltration refers to the movement of water into the soil layer. The rate of this movement is called the infiltration rate. If there is more rainfall than the infiltration rate then water will collect on the surface and runoff will begin. Later the water evaporated.



In this graph we see a the water infiltrate very quick. This was due to the soil, not having any water in it. The soil was quick to suck up the water poured on it. Any soil that is heated up by the sun is left dry and is very quick to tae in water when it rains.



Conclusion:

This graph is showing the time taken for infiltration of both factors. From this it is easy to determine whether the water infiltrates quicker when soil is dry or muddy. The water has infiltrated in far less time for dry soil than muddy soil. This is can be explained by considering that muddy soil would already be full of water. Water infiltrates fast into a dry materia l and then over a long time slows down, as the material becomes wetted. The quantity of water in soil greatly affects the infiltration rate of the soil. The rate of infiltration is higher when soil is dry and decreases as the soil is wetter. Dry soil also tends to have cracks in it, and water can get through much quicker.

Quotes:

Soil saturation: Like a wet sponge, soil already saturated from previous rainfall can't absorb much more, thus more rainfall will become surface runoff.

Soil characteristics: Some soils, such as clays (usually dry), absorb less water at a slower rate than sandy soils. Soils absorbing less water result in more runoff overland into streams.

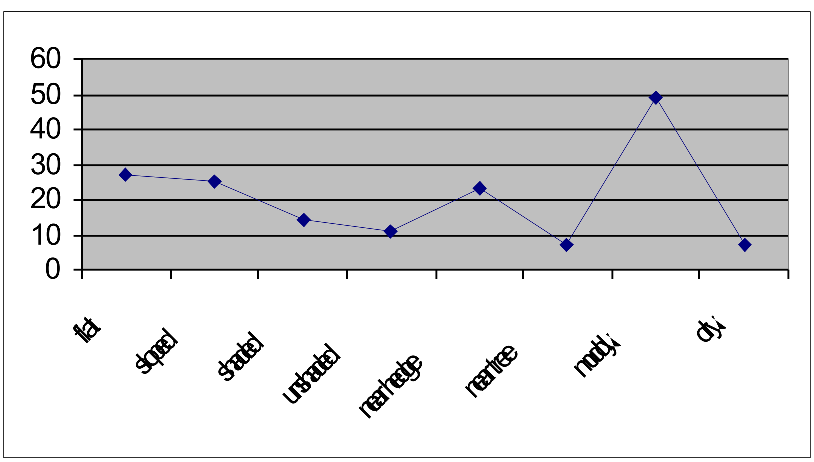
My prediction suggested the same outcome, therefore it is correct.

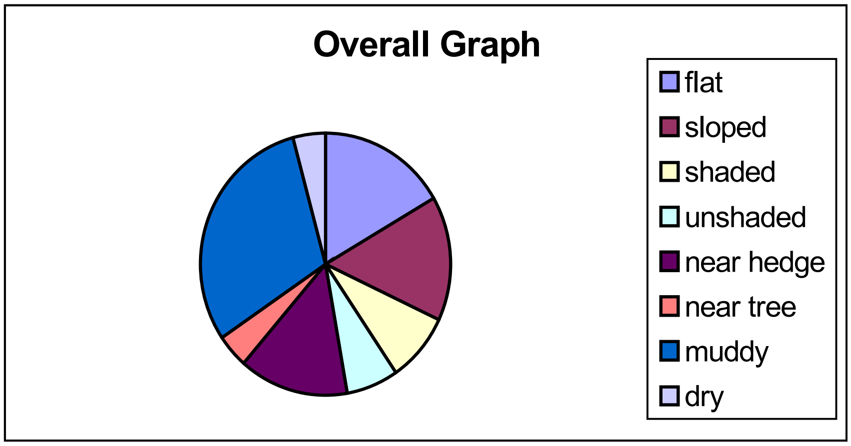
Overall Conclusion

From all the experiments its obvious that when the second and third attempts were made the time taken increased. This is because the water had already taken a certain amount of water in.
From analysing the results the order of the factors affecting infiltration rate most or least are seen.

Muddy Soil — ***Slowest to Infiltrate***
Flat Land
Sloped Land
Near a Hedge
Shaded
Unshaded
Near a Tree
Dry Soil — ***Fastest to Infiltrate***

The graph below shows all the factors, and the time they took to infiltrate. The time plotted is the average over all three recordings.





The purpose of the graphs is to show which factor affect infiltration the most. The graph displays all the results together, therefore it is easy to draw a conclusion.
The infiltration rate depends upon the size and number of air spaces between the soil partials and other soil structures. Changing the porosity of the soil therefore alters the permeability of the soil.

Quote:

Precipitation: The greatest factor controlling infiltration is the amount and characteristics (intensity, duration, etc.) of precipitation that falls as rain or snow. Precipitation that infiltrates into the ground often seeps into streambeds over an extended period of time, thus a stream will often continue to flow when it hasn't rained for a long time and where there is no direct runoff from recent precipitation.

Advantages of Infiltration:

Infiltration of storm water has a number of advantages and disadvantages. The advantages of infiltration include both water quantity control and water quality control. Water quantity control can occur by taking surface runoff and infiltrating this water into the underlying soil. This reduces the volume of water that is discharged to receiving streams, thereby reducing some of the potential impacts caused by an excess flow as well as increased pollutant concentrations in the receiving stream.
Infiltration rate, the rate at which water moves into the soil surface, correlates with organic matter levels, earthworm numbers and soil stability. Good infiltration reduces erosion and helps keep vital topsoil and organic matter in place. In addition, water that infiltrates into soil is less likely to run off fields and carry soil, nutrients and chemicals to nearby water sources.

Disadvantages of Infiltration:

Infiltration may not be appropriate in areas where groundwater is a primary source of drinking water due to the potential for contaminant migration. This is especially true if the runoff is from a commercial or industrial area where the potential for contamination by organics or metals is present. Also, the performance of infiltration BMPs is limited in areas with poorly permeable soils. In addition, infiltration BMPs can experience reduced infiltrative capacity and even clogging due to excessive sediment accumulation. Frequent maintenance may be required to restore the infiltrative capacity of the system. Care must also be taken during construction to limit compaction of the soil layers underlying the BMP

Practical Benefits

There are many practical benefits of my study for farmer and gardeners. When planting something gardeners must consider the suitability of the land chosen, in order to ensure it grows well. The rate at which certain areas infiltrate, must be considered.
For instance an unshaded area would be better than a shaded area.
If the soil is taken apart by growing roots or other organic material then more water infiltrates. This is due to pores in the structure of the soil, which allow water to get through easier. Due to all this the surface for planting things must be closely observed.
All farmers consider infiltration so they can have the best possible growth for their crops. Farmers rely hugely on growing crops so he/she must consider all factors that would affect the rate of infiltration in a certain area.
From the experiment it is shown that soil infiltration is affected by different conditions the soil is in.