Soil Permeability Demonstration

Grade Level:
6-12

Subject Area:
Soil science,
Aquaculture

Time:
This will take one hour to drill holes in the bucket and acquire the various soils. This will take one hour to conduct this experiment. It will take 15 minutes to discuss results with students and relate results to natural ecosystems and function of various land types due to soil type.

Student Performance Standards (Sunshine State Standards):
03.01 Employ scientific measurement skills (SC.912.E.7.8; SC.912.L.14.4; SC912.S.3.1, 9; MA. 912. A. 1.5; MA.912.S.4.2; MA.912.S.5.1, 3; MA.912.S.5.2, 3, 4, 5).
03.02 Demonstrate safe and effective use of common laboratory equipment (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.14.6SC.912.L.16.10; SC.912.L.17.12, 14, 15, 16; MA.912.A.2.1, 2)
03.06 Interpret, analyze, and report data (SC.912.L.16.1; SC.912.N.1.1, 2, 3, 4, 6, 7; SC.912.N.2.2, 5; SC.912.N.3.1; SC.912.N.4.1; MA.912.S.3.1, 2; MA.912.S.4.2; MA.912.S.5.1, 2, 3, 4, 5).
13.06 Determine soil types, land slope, and other factors to consider in choosing a location for a man made pond or other aquaculture operation (SC.912.E.6.4; SC.912.7.4; SC.912.L.17.12; SC.912.L.17.4, 5, 10, 15, 16, 19; SC.912.N.1.1; SC.912.N.1.2; SC.912.N.2.4; SC.912.P.12.12; MA.912.A.1.2, 4, 5; MA.912.A.5.1, 4, 7; MA.912.A.10.1, 2; MA.912.G.1.1; MA.912.G.2.7; MA.912.G.4.1, 4, 5; MA.912.G.5.1, 3, MA.912.G.8.2; 4; MA.912.S.1.1, 2; MA.912.S.2.2; MA.912.S.3.6).
15.03 Identify and describe important growing facility construction and site requirements (SC.912.L.17.16; SC.912.P.10.14, 15; MA.912.A.1.1, 2, 4, 5; MA.912.A.5.1, 4, 7; MA.912.A.10.1,2; MA.912.G.1.4; MA.912.G.2.7; MA.912.G.4.1, 4, 5; MA.912.G.6.1, 2, 4, 5; MA.912.G.8.2).

Objectives:
1. Students will be able to describe soil types.
2. Students will be able to explain the relationship between soil type and permeability of water.
3. Students will be able to identify land uses including pond aquaculture based on permeability of water.

Abstract:

Soils vary throughout regions, states, counties, and small parcels of land. The soil types are important in drainage of water because of their permeability to water. This activity will demonstrate to students that there are differences in soils and each has different permeability to water. They will gain knowledge about how soil type affects drainage of any land experiencing rain and how this relates to site selection for aquaculture ponds. This demonstration of soil types is easy, inexpensive, and has application for aquaculture, aquatic sciences, wetlands, agriculture, and forestry.

Interest Approach:

Land drains differently depending on the terrain and soil type present. Soil that allows water to permeate easily is less vulnerable to flooding than less permeable soil types. Soil types influence flooding, where wetlands occur, and what are the potential uses of the land. Ponds, including aquaculture ponds, are commonly built in silt soil that has low permeability to water when compared to other soil types.

Student Materials:

1. 5-gallon buck with holes drilled in the bottom
2. Sandy soil
3. Cat litter
4. Rocks
5. Water
6. Clock/stopwatch
7. *Soil Permeability Observations* handout

Teacher Materials:

Material	*Store*	*Estimated Cost*
5-gallon bucket/group	WalMart, Home Depot	$5 and up
Sandy soil	WalMart, Lowe's	$4 and up (free if just collected)
Cat litter	WalMart, Target	$5 and up
Rocks	WalMart, Lowe's	$5 and up (free if just collected)
Water	NA	NA
Clock/stopwatch	WalMart, Target	$16 and up
Soil Permeability	NA	NA

Observations handout

Student Instructions:

1. Gather one set of materials for the group.
2. Suspend the bucket (holes pre-drilled) off of the ground a few inches or more. It may be placed on wood, bricks, or hung.
3. Add a known amount of water to the bucket with holes. If a five-gallon bucket is used, three gallons is sufficient.
4. Measure and record how long it takes for the water to completely drain from the bucket with holes.
5. Fill the bottom three inches of the bucket with rocks.
6. Add the same amount of water to the bucket on top of the rocks.
7. Measure and record how long it takes for the water to completely drain through the rocks and out the holes in the bucket.
8. Remove the rocks.
9. Repeat steps 5-8 using sandy soil and then cat litter.
10. Compare the results.
11. Discuss how soil type affects permeability of water.
12. What type of soil should be used for an aquaculture pond?

Teacher Instructions:

Preparations:

1. Obtain buckets or similar containers and drill small holes (1/8" diameter) in the bottom of the container.
2. For a 5-gallon bucket drill 15-30 holes spread over the bottom.
3. Take buckets outside and fill with water with various soil types in the bottom of the bucket.
4. Measure the amount of time it takes for the water to completely drain out of the bucket through the soil and holes. If the draining is too slow then add more holes to the bucket.
5. Set up the buckets on something to suspend them off the ground so water can drain out the holes.

Activity:

1. Guide students through the instructions.
2. Supervise students.
3. Review results with students.

Post work/Clean-up:

1. Dispose of soils appropriately.
2. Store buckets and remaining materials.

Anticipated Results:

Water will drain slower as the particle size of the soil decreases. This means the higher the clay (smallest particle size) content, the slower the water will drain. Water may not drain out of the bentonite clay (cat litter).

1. Students will gain understanding on permeability of water in various types of soils.
2. Students will be able to relate possible soil types which occur in various natural ecosystems and why these natural ecosystems occur. Examples are wetlands, ponds, deserts, and agricultural lands.
3. Students will be able to make recommendations on preferred soil type for ponds to be constructed.

Support Materials:

1. *Soil Permeability Observations* handout
2. Publication: Wellborn, T.L. 1988. "Site Selection of Levee-Type Fish Production Ponds." *Southern Regional Aquaculture Center* Publication Number 100.
3. Publication: Stone, N. 1999. "Renovating Leaky Ponds." *Southern Regional Aquaculture Center* Publication Number 105.

Explanation of Concepts:

Soil types and water permeability are essential for any type of agriculture including aquaculture. The results will teach students that soils with high clay content will retain water. Other soils will allow water to percolate through them. Aquaculture ponds should be built in soil with as high of clay content as possible. Bentonite clay (cat litter is also made of bentonite clay) is often used to seal leaky ponds, although it is not available everywhere without trucking it long distances.

 ***Support Materials*** 

Soil Permeability Observations

Name: _____

Soil Material	Observations	Time for Water to Permeate
EMPTY		

Water sources for ponds vary between locations. Water sources include wells, springs, streams, canals, and watershed runoff. A well is the best source of water for an aquaculture pond. Use of well water helps prevent introduction of unwanted organisms including macroalgae, fish, and fish eggs. If these unwanted organisms are introduced into an aquaculture pond, they can proliferate rapidly and cause problems with the culture of the desired fish or crustacean in the pond. The water source should provide approximately 25 gallons per minute, at least for more intensive ponds and higher stocking densities. The water should be free of pesticides, agriculture chemicals, or other pollutants. In freshwater, the alkalinity should be at least 80 ppm. This will buffer the water from large changes in pH. Water typically enters the pond through a pipe attached to the well or other water source. The water entering each pond is controlled by valves.

Soil types vary greatly. The type of soil the pond is constructed with will determine how well the pond will hold water. The smaller the soil particles the tighter they pack together and the better they will hold water. Silt is the best small soil particle for pond construction. Larger particles, such as sand, will not pack well together and will cause water to seep away from the pond and can drain the entire pond. Wet soils such as those found in wetlands can hold water but may not make good material to build a pond. This is because the soils may only hold water because they are saturated, or full of water, and when moved and reshaped into a levee of a pond, they can leak. It is also important to know what the water table is where you plan to have a pond. The water table is the depth of the natural water present in the ground. This can vary between seasons with summer water tables typically being most shallow. To determine the water table, dig a hole into the ground and leave an exposed hole, within a day the hole may be filled with water, if so that is the water table at that time. The water table is important because as you dig a pond you may enter the water table and it will fill with water. This will not prevent the pond from being constructed, but it will make it very difficult to drain during harvesting of the aquaculture pond. As the pond is drained, new water will seep up from in the ground and re-fill the pond. Soils can also accumulate unwanted chemicals such as pesticides. It is important to have the soil tested for pesticides before spending money to build a pond. If pesticides are present, then consider relocating the site for building the pond.

The topography of the land is important to consider before building a pond. Building a pond on a slight slope of 2-10% is best because if will allow for rainfall to run off and flow away from the pond. If a pond is built at the bottom of a hill, it will accumulate water during rain and run off and may be hard to drain and prevent flooding. Building a pond on a flood plain or low lying land can also cause problems with flooding. Land in a flood plain will periodically become flooded. If ponds are located in a flood plain, the water level can raise so high that water crests the levees causing exchanges between the ponds. Fish can also exchange between ponds or can swim away and be lost.

Aquaculture ponds typically require the use of mechanical aeration to maintain adequate dissolved oxygen concentrations. Therefore, it is crucial to have electricity at the pond site because most aerators are electrical. There are now solar powered aerators available, but the cost is very high in comparison to standard electrical models.

Wind direction and orientation of the pond is important, especially with larger ponds. Positioning a pond at a right angle to the prevailing winds will reduce erosion of the levees. Parallel winds increase wave action and the likelihood of erosion of the levees where the wind driven waves are hitting. When multiple ponds are constructed in an area, they are typically oriented side by side to each other. The levees should be about 20 feet wide for the main levees and 16 feet wide for other levees. This is adequate for vehicles and large trucks to drive on the levees. The larger the pond, the less expensive it is to build on a per acre basis. Ornamental fish ponds in Florida are about 1/10 of an acre while catfish ponds are often 10 acres in size. The shape of the pond affects construction costs because a rectangular pond actually requires less dirt to be moved than a square pond of the same size. Ponds should have about 1-2 foot of freeboard, or height from the top of the water to the top of the levee, this will reduce erosion and prevent breach of the levee during heavy rainfall.