Student Scientists: Make Your Bed

Activity #2 Study Soil
While we are still talking about soil, let’s check three other soil properties that will affect your garden:

- compaction
- pH
- drainage

If your garden site has a lot of ‘foot traffic’ the soil may be COMPACTED. COMPACTION can cause problems for roots. When the edible parts of plants grow underground, compaction causes irregular growth.

To determine if your soil is compacted:

Look - is there a well-worn path? Has the garden been walked on a lot where you will be planting?

Examine- is your garden a newly created site? Is it close to a building? Is it in an area where people have walked or cars have driven?

Compaction can be reduced by shoveling and loosening soil, using a tiller, or by building a raised bed.

Based on your knowledge of the use of this site, do you think your soil is compacted?___________

What will you do to reduce compaction?

________________________

________________________

________________________

________________________
Soil can be called “sweet” or “sour” but it has nothing to do with taste.

Sweet soils are also called ALKALINE.
Sour soils are also called ACIDIC.

This is chemistry. Although chemistry sounds like a difficult science we can a simple thing about the chemistry of water.

All things are made of ATOMS, but we can’t see them because they are so small. Even high powered microscopes can’t see atoms. But atoms don’t stand alone. They are almost always in groups called MOLECULES.

Here is a water molecule called H₂O which means it has:
- 2 “H” HYDROGEN atoms
- 1 “O” OXYGEN atom

Remember! The water molecule is called H₂O

It has two atoms of ________________________
It has one atom of ________________________

What is pH?

pH is a nickname for the chemistry of plain old water!

See how “pH” and “H₂O” both have a capital H? You just learned that the capital H stands for hydrogen, and the capital O stands for oxygen.

Chemistry happens all around us; in the air, the soil and in our bodies. Remember, pH describes the chemistry involved wherever water is!

That includes our bodies, and plants, because water is found in both.
Water molecules don’t always stay together. When they split apart, the 'pieces' are called IONS. When we test for pH, we are checking for loose ions.

Everything is made up of molecules. Loose ions affect the chemistry of anything with water in it. That includes our bodies and plants. Loose ions in the soil affect how plants get their nutrients. That is why we check pH. It tells us if the soil is good for plants.

Some plants like sweet (alkaline) soil and some like sour (acidic) soil. This is not just a matter of preference. They can actually get sick if the soil is not right for them.

People test soil pH so they can choose the right plants for their soil. They can also adjust the soil pH for plants like vegetables. Most vegetables like soil that is slightly acidic. This means the pH should be between 6.5 and 7.

<table>
<thead>
<tr>
<th>Plants that like Acid soils</th>
<th>Plants that like Alkaline soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beans</td>
<td>Oregano</td>
</tr>
<tr>
<td>Greens</td>
<td>Bellflowers</td>
</tr>
<tr>
<td>Broccoli</td>
<td>CrownVetch</td>
</tr>
<tr>
<td>Onions</td>
<td>Cranesbill</td>
</tr>
<tr>
<td>Peppers</td>
<td>Speedwell</td>
</tr>
<tr>
<td>Potatoes - very acidic</td>
<td>Pincushion</td>
</tr>
<tr>
<td>Blueberries</td>
<td>Arborvitae</td>
</tr>
<tr>
<td>Lily of the Valley</td>
<td>Redbud</td>
</tr>
<tr>
<td>Peony</td>
<td>Green Ash</td>
</tr>
<tr>
<td>Forget me Not</td>
<td>Norway Maple</td>
</tr>
<tr>
<td>Hosta</td>
<td>Sycamore</td>
</tr>
<tr>
<td>Creeping Phlox</td>
<td></td>
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<tr>
<td>Douglas Fir</td>
<td></td>
</tr>
<tr>
<td>Holly</td>
<td></td>
</tr>
<tr>
<td>White Pine</td>
<td></td>
</tr>
<tr>
<td>Crabapple</td>
<td></td>
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</tbody>
</table>
Soil pH is important but often overlooked by many gardeners.

Let's test your soil!

The easiest way to test your soil is with a purchased soil pH test kit. Anyone can do this, so you can check soil in a school garden or home garden. It does not need to be done every year, but it is an especially good idea when you are starting a new garden site. It is good to test soil pH in existing gardens if you do not know what it is.

Follow the directions on the kit. Usually this involves taking a couple spoonfuls of soil and mixing it with water. The water must be distilled or de-ionized so that it does not add any of those loose ions to the soil! A special kind of paper called litmus paper, is placed in the water and will change color to show the pH of the soil.

\[ \begin{array}{cccccc}
1 & 6 & 6.5 & 7 & 7.5 & 8 \\
\hline
\text{acidic} & \text{neutral} & \text{alkaline}
\end{array} \]

From the testing you did, what is your estimate of the soil pH?

As we've said, most vegetable plants like soil that is slightly acidic (between 6.5 and 7). Will you have to adjust your soil pH?

Two products, lime and sulphur, are available to add to soil to change its pH. An adult can do this. Another way is to adjust pH is to add organic matter, which is good for an soil.
Next we will check your garden soil for drainage. Although plants must have water in the soil to live, too much can be a problem for most plants. Some shrubs and trees and other perennial plants can tolerate wet ground. If you are planting vegetables, you must have soil that will drain well.

Compacted soils often do not drain well and neither do many clay soils. Here is a way to test and see how well your soil drains. You will need some tools such as a shovel, a yard stick and a bucket.

On a day when it has not rained in two days, choose a spot in your garden to dig a hole that is at least 18-24" deep. If your soil is very compacted, rocky or very dry, this will take some work. Take turns digging. Remember that a shovel is a tool and must be used with caution. Make sure hands and feet are kept away from the hole you are digging.

Once the hole is done, dump water into it until it is filled to the top. Let this drain for several hours or until the next day.

Refill the hole with water to just below the top. Place a measuring stick or yard stick in the center of the hole and stand it up straight. Make a note of where the water level is. Measure again after 30 minutes. Measure again after another 30 minutes. Make sure the stick is in the same spot each time you measure.

If the water level drops less than 1/2" in an hour, your site is poorly drained.

If the water level drops 1/2" to 1" per hour, your site is well drained but may not be able to drain well after a heavy storm.

If the water level drops more than 1" per hour, you have very well drained soil that is suitable for vegetable plants!

Based on the testing you did, how would you describe your soil?

__________________________________________________________
You may have well draining soil, but your garden will still have water problems if it is in a 'low-lying' area. If your garden appears to be flat, check to see that it is not lower in the middle.

If the site is too hilly, you may have trouble with erosion. As a class, make a visual examination of your garden site. Is it in a low spot? Is it on a hill?

Based on your examination, how would you describe your garden site?

The last two things we will examine are accessibility and the presence of insect or disease problems.

Is your garden easy to get to? Is it ACCESSIBLE to people who can't walk easily to the site?

What is your water source for the garden?

You may have no way of telling if there might be an insect or disease problem in an existing garden if you know nothing about its history. Sometimes, certain plant diseases can stay in the soil. If you do know that the garden has had problems in the past, choose different plants than those previously planted or choose disease resistant varieties. This is part of good IPM.

After examining our garden site, I think it should be:

- a good place for a vegetable garden
- changed to a different location
Vocabulary:

accessible - easy to get to

acidic - being tart or sour due to having a lot of hydrogen ions

alkaline - not sour, having few hydrogen ions

atoms - the smallest part of any thing; atoms make up molecules

clay - the smallest of the soil particles; when wet it is sticky and when dry it is very hard

compaction, compacted - something that is closely packed together and dense

determine - to decide to act on something based on information you have

drainage - the movement of water or other liquid away from its source

estimate - to make a best guess based on information you have

existing - something that is there and has been; not newly formed

hydrogen - the most abundant of all the gases in the universe and is part of the water molecule

impaired mobility - being unable to walk or move easily from one area to another

ions - an atom or group of atoms (molecules) that have become unbalanced

loam - soil that is made up of sand, silt and clay and organic matter

molecules - the smallest particles that anything can be divided into without changing its chemistry (molecules are made up of atoms)

oxygen - an element that is found in the atmosphere and also as part of the water molecule
properties - characteristics or traits of something

sand - the largest sized soil particles, anything bigger would be a piece of stone

silt - a type of soil particle sized between the smallest (clay) and the largest (sand)

Review

Before any vegetables or other plants go into the ground, a gardener or farmer examines the garden site for:

- Soil texture, soil drainage, soil pH
- Amount of sun and shade and wind
- Accessibility to the garden and a water source
- Existing problems such as insects, disease and erosion

The best soil for a vegetable garden is loam soil, a mixture of sand, silt and clay. It should be well drained and have a pH of 6.5-7.

Vegetables need air circulation but not strong wind. They need at least 6-8 hours of sunlight but 8-10 hours are best.

Compacted soil is not good for plant roots. Compaction can be reduced by breaking soil up with a shovel, adding organic matter or creating a raised bed.

pH is a measurement of the chemistry of water. Water is made up of the molecule H2O. When this molecule splits into ions, these loose ions can affect water chemistry in humans, animals and plants. We can check soil pH to see if it is right for plants before we start our garden.

pH tells us if a liquid is alkaline or acid.

Gardens should be placed where water drains away from them but if the site is too hilly, erosion may occur. You can test soil in a garden to see how quickly water drains from it. This is called a percolation or 'perc' test.

Try to place gardens where they are accessible to people and a source of water.

Examining these properties of a garden site will help your garden be successful!

Congratulations, you have used some simple science to have a great garden!
pH is always measured from 1-14, 7 is neutral. Using the chart below, find the pH of some of the things you use in your house:

<table>
<thead>
<tr>
<th>pH &quot;value&quot;</th>
<th># of hydrogen ions</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10,000,000</td>
<td>battery acid</td>
</tr>
<tr>
<td>1</td>
<td>1,000,000</td>
<td>sulfuric acid</td>
</tr>
<tr>
<td>2</td>
<td>100,000</td>
<td>lemon juice, vinegar</td>
</tr>
<tr>
<td>3</td>
<td>10,000</td>
<td>orange juice, soda</td>
</tr>
<tr>
<td>4</td>
<td>1,000</td>
<td>tomato juice</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>black coffee</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>milk</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>pure water</td>
</tr>
<tr>
<td>8</td>
<td>0.1</td>
<td>eggs</td>
</tr>
<tr>
<td>9</td>
<td>0.01</td>
<td>baking soda</td>
</tr>
<tr>
<td>10</td>
<td>0.001</td>
<td>milk of magnesia</td>
</tr>
<tr>
<td>11</td>
<td>0.000 1</td>
<td>ammonia</td>
</tr>
<tr>
<td>12</td>
<td>0.000 01</td>
<td>soapy water</td>
</tr>
<tr>
<td>13</td>
<td>0.000 001</td>
<td>bleach, oven cleaner</td>
</tr>
<tr>
<td>14</td>
<td>0.000 000 1</td>
<td>liquid drain cleaner</td>
</tr>
</tbody>
</table>

lemon juice ______ eggs ______
orange juice ______ milk ______
baking soda ______ soapy water ______
Test Yourself!

1. You tested the soil in your garden with a pH test kit and found out that it has a pH of 10. This is good for plants.
   ______true  ______false

2. When you did a percolation test in your garden, the second bucket of water you poured in did not go down at all. This means it has good drainage.
   ______true  ______false
Deciding if soil is compacted takes a bit of investigation. What is the site used for? How much foot traffic does it receive? What about cars, construction vehicles or tractors? In a turf area, compaction can often be “seen” without digging. Along sidewalks, grass tends to not do well but weeds will often be found. This is because weed roots can tolerate and take advantage of hard, compacted soil where grass roots and other plants would not survive. Loosening compacted soil is not easy work. Contact some professionals and request free assistance!

This activity introduces chemistry in its simplest form. The difficult part is understanding the abstract idea that everything is made up of atoms and molecules! A broken water molecule (its bond has been broken) creates two ‘pieces’ or ions. pH is a way to count these loose ions that are not part of a complete water molecule. They affect other molecules around them, like molecules of nutrients and other water molecules. That is all the chemistry you need to know to teach this lesson. Simply put – pH is counting loose ions which are ‘broken’ molecules and understanding that loose ions affect other molecules.

You and some of your students may have heard or know that plants can become unhealthy if they are not getting the nutrients, including iron they need. This is not always because the nutrients aren’t there, but may be due to the chemistry going on with the soil and water. Many common ornamental plants become yellow when the pH is not right. Often that same plant “likes acidic soil.” Too few or too many of those loose ions are affecting the number of soil nutrients that plant needs.

A pH test kit is very safe to use but students should be reminded that they should never play with a test kit or any chemicals under any circumstances (FYI: Some litmus papers are created to test human pH by placing on the tongue). Kits are safe when used as directed but are not toys. A chart at the end of this unit can be used to extend the discussion of acidic and alkaline. Many common household products test to both sides of the pH scale. Extremes in pH can be caustic. Remember to use distilled or ‘de-ionized’ water when testing for pH. Those free ‘loose ions’ have been removed.
It’s a good idea to test in more than one hole if you can achieve this. Digging those holes may take some work, and will probably not be something to do at the last minute or while students are waiting. A hole may be pre-dug and students may be able to clean up loose soil before water is added. If you have non-compacted loam soil with few rocks and stones, lucky you! Fill the holes with water and let drain out once before the actual test with the class. This activity is an effective learning tool.

To wrap up outdoor activities, have students discuss the garden site’s topography. Is it flat or on a slope? How does this affect it? Is the site accessible for the class to visit often? Is it situated where students and adults with limited mobility will find it difficult to reach? Is water available by hose or at least close enough to use watering cans and buckets when necessary? By going over all the qualities of the garden site, have students decide if the site is acceptable or should be changed.

6. You tested the soil in your garden with a pH test kit and found out that it has a pH of 10. This is good for plants.  
   ______true  ______false  
   X (no, plant like 6.5-7 generally)

7. When you did a percolation test in your garden, the second bucket of water you poured in did not go down at all. This means it has good drainage.  
   ______true  ______false  
   X (no, it does not drain well