

Lab 7 Soil pH and Salinity

OBJECTIVE

In this lab you will learn the effect of the concentration of hydrogen ions (pH) and various salts on the fertility of a soil. You will perform some tests which are done in professional soil testing labs to quickly estimate the pH of a soil.

INTRODUCTION

Soil pH

The definition of pH is :

$$\text{pH} = -\log [\text{H}^+]$$

Since pH is a logarithmic scale, each concentration change of 1 unit means that the hydrogen ion concentration has changed by an order of 10. In reality, there are no free protons swimming around, but rather, the hydrogen loosely associates with a water molecule, forming the hydronium ion (H_3O^+).

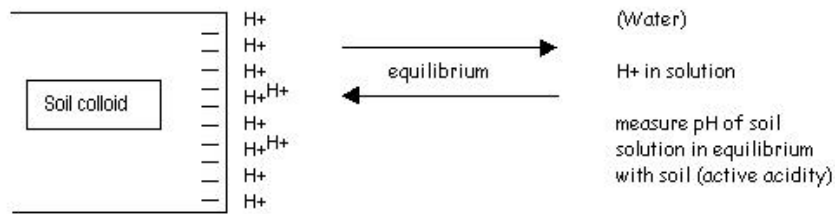
The pH of most soils range from 4.0 to 8.5. The pH of most NJ soils range from 4.0 to 6.3. The soil pH is a measure of the **active** acidity of a soil; that is, the H^+ concentration in the soil solution. As a diagnostic tool, the measurement of soil pH is a very simple and inexpensive test. It indicates whether the soil pH is in the optimum range for plants or likely to be detrimental to plant growth, and therefore whether liming materials or acidifying agents are needed. Most plants will grow over a soil pH range of 1-2 units. However, all plants have an optimal pH range. Management of soil pH is important, not because of the direct effect of hydrogen ions, but to reduce the toxicity of other ions (especially Al^{3+}) and increase the availability of plant nutrients.

Soil pH is usually measured in a soil/water suspension of a specific ratio. Commonly, ratios of 1 volume soil : 1 volume water are used. A pH meter with a glass electrode is used to measure the pH of the soil/water suspension.

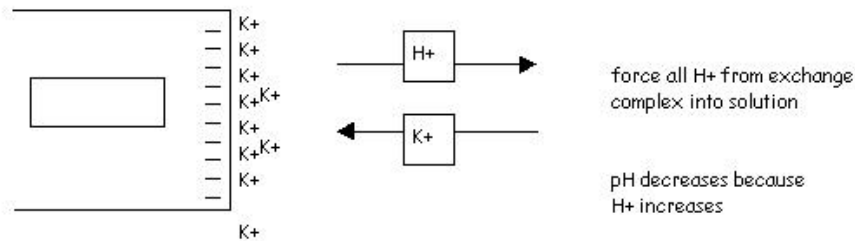
The addition of a neutral salt solution (e.g., CaSO_4 , KCl) will usually result in a decrease in *measured* pH because acidic cations displaced from the exchange complex are put into solution where they can be measured. This increase of acidic cations in solution decreases the pH, and the degree of change gives a good indication of the buffering capacity of the soil (the amount of exchangeable acidity that tends to counteract pH change).

In nature, soil acidity can increase as basic cations are leached from the soil, as is common in humid regions. Soil acidity can also be the product of microbially mediated reactions, such as nitrification, or of chemical reactions, such as the exposure of sulfide minerals to air and water (acid mine drainage).

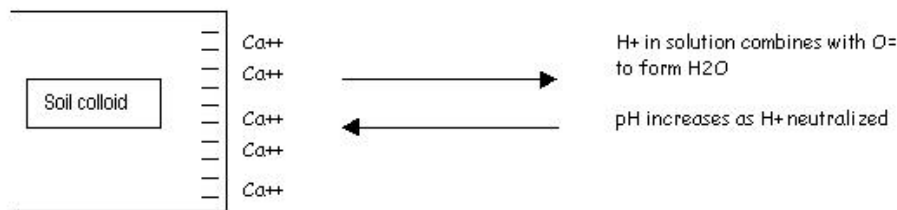
The amendment of soil with liming materials (e.g., CaO) will result in an increase in soil pH. The acidic exchangeable cations are replaced by cations from the liming material (increasing percent base saturation) and are neutralized in solution (increasing soil pH as total acidity is decreased).



Add salt: KCl at high concentration
Replace H+ with K+

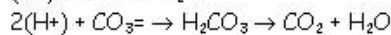
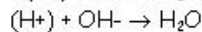
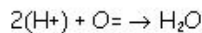


Add liming material: CaO



Neutralize: tie up H+

Use O⁼, OH⁻, or CO₃⁼



pH meters:

The pH of a solution is determined by the solution coming in contact with the **electrode**. The electrode is constructed of a special glass, which is responsive to the change in the hydrogen ion potential. The special glass is actually hydrated by the solution, and becomes a type of glass gel. The difference in electric potential between the outside solution and the inside solution (usually a mixture of silver chloride and potassium chloride; A silver wire completes the silver/silver chloride/potassium chloride reference system) generates the electrical signal which is read out in either digital or analog form.¹

For an accurate pH measurement to be obtained, several criteria must be satisfied: 1.) the electrode must be solvated. This means that it has to be soaking in an aqueous solution prior to any measurements being made. 2.) The system of the electrode must be at equilibrium. This takes into account temperature and pressure. Obviously, all the solutions should be at room temperature, including the internal solutions of the electrode. Secondly, the small plug on the side of the electrode must be unplugged for the pressure to be equal. The small plug prevents loss by evaporation of the reference solutions.

Carefully examine the electrode prior to use. The outer surface should be clean, definitely not cracked in any way, and the solutions inside should be at least 2/3 full. **Gently** wipe off from the outside of the electrode any crystalline precipitate. Use a damp towel with distilled water.

Standardize the pH meter against reference buffer solutions. Follow the directions for that particular pH meter, located beside the meter. **Rinse off** the pH electrode with distilled water between readings of different buffers and sample solutions. This prevents contamination of the next sample and skewing of the results. When you are finished, leave the pH meter soaking in the pH 7 buffer.

Soil salinity:

Soil salinity is the result of the presence of soluble salts in excess of the cation exchange capacity and/or the presence of high amounts of exchangeable sodium. If the exchangeable sodium is present in an amount greater than 15% of the exchange capacity, a *sodium effect* will be present. A high concentration of salt can affect a plant's capacity to extract water from soil due to increased osmotic potential of the soil, or salts may interfere with other plant essential ions, causing deficiencies. Salt affected soils are a severe problem for people trying to farm arid regions. High salinity can also be indicative of saltwater contamination of the groundwater. This occurs in areas where large amounts of fresh water are being pumped out to meet the demands of urban development and a body of saltwater is nearby that can creep in to fill the void.

The presence of excess salt may be identified by measuring the electrical conductivity of a water extract of a soil. Saline soils are usually identified by the electrical conductivity of a saturation extract of a soil, but routine diagnosis of salt problems are made on 1:1 and 2:1 water:soil ratio extracts.

Measurements of soil pH and soil salinity are rapid and easy to determine indicators of possibly detrimental conditions for plant growth. Such measurements are most commonly used to identify why plants will not grow on a soil.

Conductivity meters:

A conductivity meter measures the ease (lack of resistance) with which an electrical current flows through a solution. Contrary to popular belief, water itself does not easily conduct electricity. For a current to be conducted, there must be a charged specie (an ion) present. Water does self-ionize, but to such a low degree that it has been estimated that one molecule in 555,000,000 is ionized². In industrial applications of water (cosmetics, pharmaceuticals, etc.) one of the tests of purity is the resistance of water to electricity. So, what you will be measuring in lab is the presence of ions in the soil solution. These ions can come from many sources, such as fertilizers, liming, applications of rock salt to de-ice walks and roadways, infiltration of brackish water into the water table, etc. While some ionic activity is desirable (as it indicates the presence of plant nutrients), too much ion concentration in the soil solution causes osmotic problems for plant roots, even to the point of death.

Just like a pH meter, a conductivity meter can be standardized against known salt solutions. Take the same precautions with a conductivity meter as with a pH meter. Rinse between each sample to avoid contamination.

NOTE - There is a relationship between pH and soil salinity. In general, the greater the amount of salt or exchangeable bases in the soil solution, the higher the pH. In NJ, a large

portion of the exchangeable bases have been weathered away - unless replaced by liming. Hydrogen now dominates the exchange complex and lowers pH. In arid climates, exchangeable bases are generally not weathered away because rainfall is so low. Therefore, in such areas pH can be relatively high (> 8).

Remember- pH and salinity in soil are closely associated with exchange processes. If the soil has many exchange sites, there are potentially more ions to act as a buffer against change in the soil solution. Also, some cations form bases (e.g., Na^+) and some form acids (e.g., Al^{3+}) when associated with the soil solution.

PROCEDURES

Soil pH

- 1) You have two different soils. Weigh out five 25 g subsamples of each soil and place into separate paper cups. Make sure your cups are labelled with soil name and the treatment. You will end up with 10 cups of soil.
- 2) To 2 cups in each soil series, add 20 mLs of distilled water. One sample is the control. The second sample will be used for salinity measurement. To the remaining 3 cups add, 20 ml 1N KCl solution to one, 20 ml .01 M CaSO_4 solution to a second, and 20 ml .01 N CaO solution to the third.
- 3) Stir the suspension.
- 4) Let stand for 30 minutes.
- 5) Stir and measure soil pH. Do not jam the electrode down into the soil!
- 6) SAVE your control **sample!**

Soil Salinity

- 1) Examine the conductivity electrode for any possible damage. Rinse with distilled water and begin the measurements of the standard solutions (0, 100, 200, 500, 1000, 2000 and 3000 ppm NaCl). Record the measurements and graph them against the concentration of the standards.
- 2) Take the 4 cups of the soil containing water and filter them. Combine the filtrates of the same soils. Two have been used for pH and two have not been used
- 3) Collect filtrate, and measure electrical conductivity on each of the 2 H_2O samples.

RESULTS

Soil/Texture	pH				Elec. Cond. (dS/m) ** H ₂ O
	*H ₂ O	KCl	CaSO ₄	CaO	
Downer – sand					
Penn – sandy clay loam					

* Save these and filter them for the electrical conductivity experiment.

** 1 dS/m = 1 decisiemen/meter = 1mmho/cm
= approximately 640 ppm salt in solution (depends on which salts)