Unlocking the Secrets in the SOils

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ND Soil Health Team
long LIVE the SOIL

There’s an amazing amount of life in healthy soil. More importantly, that living resource is also life-giving.

That’s why USDA’s Natural Resources Conservation Service is working with America’s farmers and ranchers to keep it healthy and functioning—for life.

Visit www.nrcs.usda.gov to learn more.

USDA is an equal opportunity provider and employer.
What is -- \( pH \)

- NO !! IT'S not, Pizza House, Philadelphia, Potrero Hill
- YES - Potential of Hydrogen
Tell us, in layman's terms, what your breakthrough means.

Certainly.

\[ K - \frac{4n^3 \sqrt{P}}{7} - 4 \cdot \varepsilon \cdot L \frac{4L}{5T} \]
Potential of Hydrogen

\( \text{pH} \) is an abbreviation or symbol which stands for Potential of Hydrogen.

The pH scale is a manner of describing the level of acidity or alkalinity solution in water. The basic formula of pH is \( \text{pH} = \log_{10}(1/[H^+]) = -\log_{10}[H^+] \) and the H+ of the formula represents the hydrogen ion in the solution. The pH has three basic stages.

Each stage of pH depend on the amount of acid or alkali that is included in the solution. The stages are starts at the point 7 which is well known as freshly distilled water (pure solution without acid or alkali).

And when the solution contains more acid than freshly distilled water, the number of pH stage decreases, and when the solution contains more alkali than freshly distilled water the number of pH stage increases.
Potential of Hydrogen

Hydrogen ion concentration as pH of precipitation, 2002

National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu
Potential of Hydrogen

- NITROGEN
- PHOSPHORUS
- POTASSIUM
- SULFUR
- CALCIUM
- MAGNESIUM
- IRON
- MANGANESE
- BORON
- COPPER
- ZINC

The general relation of pH to the availability of plant nutrients in the soil: the thicker the bar, the more available the nutrient.
Potential of Hydrogen

![Diagram showing pH optimum for crop growth]

- Potatoes
- Permanent Pasture
- oats
- Linseed
- Ryegrass Mixture
- Oilseed Rape
- Wheat and Maize
- Peas/Beans
- Barley
- Field Vegetables
- Field Brassica
- Sugar Beet

![Images showing low and high pH]

- Low pH
- High pH
Potential of Hydrogen

<table>
<thead>
<tr>
<th>Crop</th>
<th>Normal Growth pH Range</th>
<th>Recommended pH Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>alfalfa</td>
<td>6.5 - 7.5</td>
<td>6.6 - 7.0</td>
</tr>
<tr>
<td>barley</td>
<td>6.3 - 7.0</td>
<td>6.3 - 6.5</td>
</tr>
<tr>
<td>birdsfoot trefoil</td>
<td>6.0 - 7.0</td>
<td>6.3 - 6.5</td>
</tr>
<tr>
<td>clovers</td>
<td>5.8 - 7.0</td>
<td>5.8 - 6.2</td>
</tr>
<tr>
<td>corn</td>
<td>5.8 - 7.0</td>
<td>5.8 - 6.2</td>
</tr>
<tr>
<td>grasses</td>
<td>5.8 - 7.0</td>
<td>5.8 - 6.2</td>
</tr>
<tr>
<td>oats</td>
<td>5.8 - 7.0</td>
<td>5.8 - 6.2</td>
</tr>
<tr>
<td>soybeans</td>
<td>6.5 - 7.5</td>
<td>6.6 - 7.0</td>
</tr>
<tr>
<td>wheat</td>
<td>6.3 - 7.0</td>
<td>6.3 - 6.5</td>
</tr>
</tbody>
</table>

pH is the negative of the power of 10 of the H⁺ molar concentration.

$10^{-7} \text{M H}^+ \text{ for pure water.}$

Neutral

Strongly Acidic

Strongly Basic

"You could put it all into bonds - but I recommend diversifying your investments to include stocks and shares as a hedge."

"Our broker says there's nothing to fear but fear itself... but, unfortunately, that's what controls the market."
Potential of Hydrogen

Heat Transfer in the Soil

SUMMER
LONG DAYS
(Radiation)

Winter
SHORT DAYS
(Radiation)

SUMMER
WARM
MOIST
DRY
COOL

WINTER
COOL
MOIST
DRY
COOL

SNOW
Mulch

MOIST
DRY
WARM

WARM
Potential of Hydrogen

How soil pH affects availability of plant nutrients

Soil pH

Optimum soil pH range: 6.2 - 7.3
Potential of Hydrogen

Soil pH affect on wheat root growth
Potential of Hydrogen

Increasing nutrient supply/nutrient concentration in plants:
- Acute deficiency
- Hidden hunger
- Optimum supply
- Luxury supply
- Excess supply
- Acute toxicity

Nutrient ranges:
- Critical nutrient range
- Low yield, low NUE
- Maximum yield
- High yield, high NUE
- Toxicity
Potential of Hydrogen

Seasonal Root Growth
Cool Season Grasses

Spring  Summer  Fall
Potential of Hydrogen

What happens to the size of a grass population when there is plenty of water, sunlight and space, and no grass eaters (like cows)?

Our population stays about the same size.

There will be more of us, but the growth will be slow.

Hard to tell... grass populations are unpredictable.

Our population will grow like crazy! #grass explosion

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Natural selection - B P #1
# Potential of Hydrogen

A guide to the optimum pH for crop growth:

- Potatoes: 5.5 - 6.5
- Wheat & Maize: 6.0 - 7.5
- Permanent Pasture: 5.6 - 6.8
- Peas & Beans: 6.0 - 7.5
- Oats: 5.5 - 7.0
- Barley: 6.5 - 7.5
- Linseed: 6.0 - 7.0
- Field Vegetables: 6.5 - 7.5
- Rye-Grass Mixture: 5.5 - 7.0
- Field Brassica: 6.5 - 7.5
- Oilseed Rape: 6.0 - 7.5
- Sugar Beet: 6.5 - 8.0
## Potential of Hydrogen

### Table 1. Tons of ECCE* lime needed to raise soil pH to 6.8 or 6.4

<table>
<thead>
<tr>
<th>Buffer index</th>
<th>pH 6.8</th>
<th>pH 6.4</th>
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<tbody>
<tr>
<td>&gt;7.1</td>
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<tr>
<td>7.1</td>
<td>0.5</td>
<td>none</td>
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<tr>
<td>7.0</td>
<td>0.7</td>
<td>none</td>
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<td>6.9</td>
<td>1.0</td>
<td>none</td>
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<tr>
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<td><strong>1.2</strong></td>
<td><strong>0.7</strong></td>
</tr>
<tr>
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<td>1.4</td>
<td>1.2</td>
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<tr>
<td>6.6</td>
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<td>1.7</td>
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<tr>
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<td>3.1</td>
<td>2.7</td>
</tr>
<tr>
<td>6.3</td>
<td>3.7</td>
<td>3.2</td>
</tr>
<tr>
<td>6.2</td>
<td>4.2</td>
<td>3.7</td>
</tr>
</tbody>
</table>

*Effective calcium carbonate equivalent.
Potential of Hydrogen

A) Effect of soil properties

a) pH

- Availability of cationic heavy metals decreases with increase in pH (Alloway and Jackson, 1991).

- Whereas, availability of Mo and elements with anionic species increases with increasing soil pH (Smith, 1996).
Potential of Hydrogen

- Battery acid
- Lemon juice
- Vinegar
- Adult fish die
- Fish reproduction affected
- Normal range of precipitation pH
- Normal range of stream pH
- Baking soda
- Sea water
- Milk of Magnesia
- Ammonia
- Lye

Source: Environment Canada
healthy soil is made of about 45% minerals, 25% water, 5% organic matter, 25% air.

Source: The Nature & Properties of Soils page 17 (Nyle Brady, Ray R. Weil)

Want more soil secrets? Check out www.nrcs.usda.gov
to keep soil happy ...

keep it **covered**
all the time with living plants
or plant residues.

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**did you know?**

Cover crops can actually help provide moisture to thirsty cash crops.

While it is true cover crops use some of the water in the soil profile, they simultaneously improve the soil structure by building soil aggregates, provide a mulch that reduces evaporation and runoff losses, and break up subsoil to increase water recharge.

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By using cover crops, no-till, and crop rotations, farmers are finding soil actually has more available water for their cash crops, especially when those crops need it. As a result, cover crops can help protect farms against weather extremes like drought.
BE PART OF THE CHANGE!

Share your story, get involved, and take pride in farming again.