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Why Soil pH Matter?

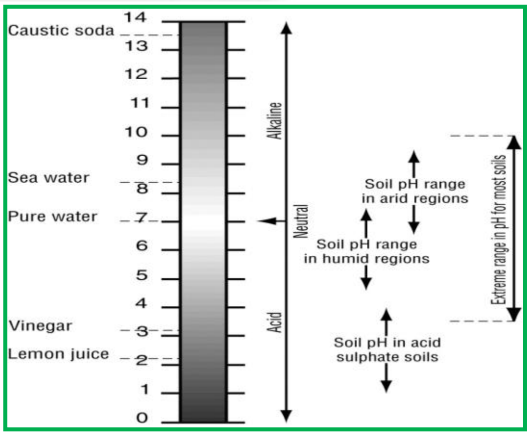
([*]Radha Chaudhary[1], Rakesh Kumar[2], Astha Pandey[3] and Bhavik Prajapati[4])
[1]Subject Matter Specialist (Soil Science), KVK, Gandhinagar
[2]Ph.D. Scholar (Agril. Chemistry), IARI, New Delhi
[3]Ph.D. Scholar (Soil Science & Agril. Chemistry), BHU, Varanasi
[4]Ph.D. Scholar (Soil Science & Agril. Chemistry), AAU, Anand
[*]Corresponding Author's email: radhaagri95@gmail.com

Soils can be naturally acid or alkaline, and this can be measured by testing their pH value. Having the correct pH is important for healthy plant growth. Being aware of the long-term effects of different soil management practices on soil pH is also important. Research has demonstrated that some agricultural practices significantly alter soil pH. Importance of soil pH can be felt as it affects the availability of all the nutrients in the soil.

What is pH? Soil pH is a measure of the acidity or alkalinity of the soil. A pH value is actually a measure of hydrogen ion concentration. Because hydrogen ion concentration varies over a wide range, a logarithmic scale (pH) is used: for a pH decrease of 1, the acidity increases by a factor of 10. It is a 'reverse' scale in that a very acid soil has a low pH and a high hydrogen ion concentration. Therefore, at high (alkaline) pH values, the hydrogen ion concentration is low. Most soils have pH values between 3.5 and 10. In higher rainfall areas the natural pH of soils typically ranges from 5 to 7, while in drier areas the range is 6.5 to 9.
Soils can be classified according to their pH value:

- 6.5 to 7.5—neutral
- >7.5—alkaline
- <6.5—acidic, and soils with pH less than 5.5 are considered strongly acidic.
- Acid sulfate soils can have extremely acidic pH values (pH less than 4).

Why soil pH? Soil is mater variable in soils because it controls many chemical and biochemical processes operating within the soil. The study of soil ph is very important in agriculture due to the fact that soil ph regulates plant nutrient availability by controlling the chemical forms of the different nutrients and also influences theire chemical reactions. As a result, soil and crop productivity are linked to soil ph value. Though soil ph generally ranges from 1 to 14, the optimum range for most agricultural crops is between 5.5 to 7.5. However, some crops have adapted to survive at soil ph outside this optimum range.



Soil ph is affected by the mineral composition of the soil parent material and the weathering reactions undergone by that parent material. For instance, in humid environments, soil acidification occurs for a long time as the products of weathering leached by water movng laterally or downwards through the soil, while in the dry environments, soil weathering and leaching are less intense, and soil ph is often neutral or alkaline.

Importance of soil pH: The importance of soil ph can be classified in two categories as a direct and indirect effect:

Direct effects

1. Toxic and destructive effect of OH and H ions on root growth: It is found that a destructive action on root tissues by acidity or alkalinity usually does not take place until the pH drops below 4.0 or rises above 9.0. When pH goes below 4.0 or above 9.0, it causes damage to root cells. There is an internal pH (4-6) of plant root cells, for which plants can only tolerate when the pH remains 4.0. Below this pH, they cannot tolerate it.

2. An unfavourable effect of low pH on the balance between the acidic and basic soil constituents available for absorption by plants: A certain balance exists between the acidic and basic nutrients which remain available for absorption by plants. At low pH, H ions are more available in soil solution whereas the basic cations are at high pH. As dominant ions are taken up by plants, at low pH, plants uptake H ions and it (excess H ions) changes the buffer capacity inside the plant, which disturbs various systems in the plants. Thus, Plants cannot grow or dies.

Indirect Effects

1. Availability of nutrients elements: pH is so important to plant growth because it determines the availability of almost all essential plant nutrients. At a soil pH of 6.5, the highest numbers of nutrients are available for plant use. Soil pH affects the amount of nutrients and chemicals that are soluble in soil water, and therefore the amount of nutrients available to plants. Some nutrients are more available under acid conditions while others are more available under alkaline conditions. However, most mineral nutrients are readily available to plants when soil pH is near neutral.

The development of strongly acidic soils (less than 5.5 pH) can result in poor plant growth as a result of one or more of the following factors:

- aluminium toxicity
- manganese toxicity
- calcium deficiency
- magnesium deficiency
- low levels of essential plant nutrients such as phosphorus and molybdenum.
- Acidic pH levels are also unwelcoming to beneficial soil bacteria.

Alkaline soils impede the availability of nutrients like iron, manganese, copper, zinc, and also phosphorous. Plants dependent on high levels of iron, evergreens in particular, perform poorly in alkaline soils.

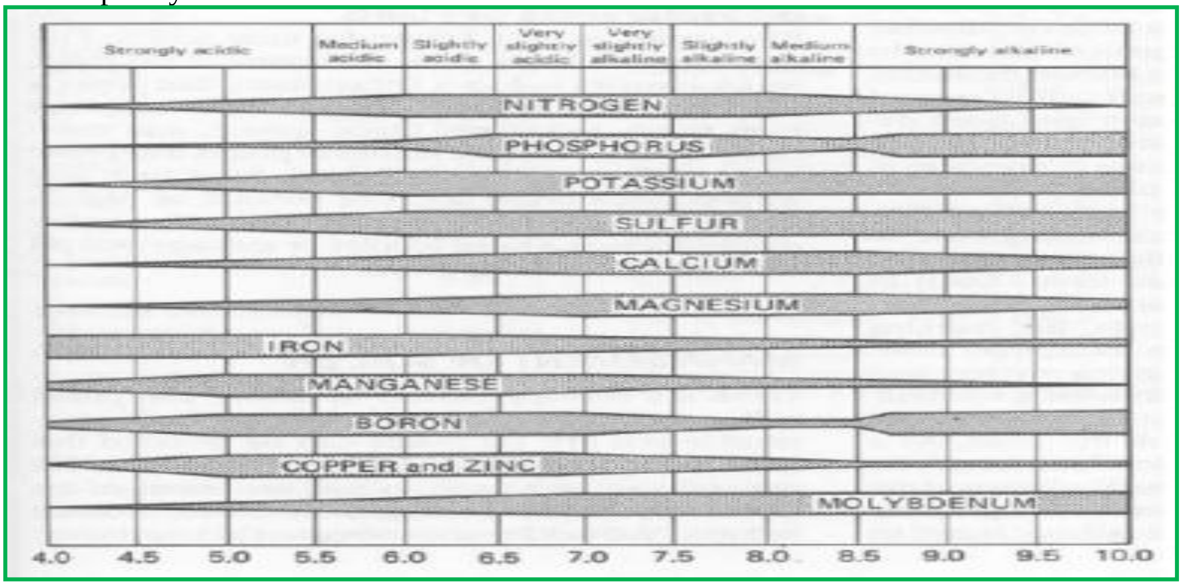


Fig. General relationship between soil pH and plant nutrients availability in minimally and moderately weathered soils.

2. Activity of microorganisms: Most bacteria and Actinomycetes generally function well at intermediate and high pH values. Generally, fungi is particularly flourishing satisfactorily over a wide pH range. Therefore, the fungal activity becomes predominant in acid soil. However, at intermediate and high pH, bacteria and Actinomycetes are strong competitors and tend to dominate the microbial activity. For bacteria, the best pH is 5.5 and above pH 5.5, nitrification takes place in the soil.

3. Physical condition of the soil: The soil pH exerts an important influence on soil structure. As soil pH is governed by the nature of cations held by colloidal particles, the cations control the aggregation of colloidal clay, and hence soil reaction indirectly influences soil structure. A soil gets deflocculated when its pH goes above 8.2-8.3. Then the particles are dispersed, soil structure gets broken down, pore space becomes clogged, water percolation is hampered and many other physical disturbances occur. At low pH, the properties of the cementing agents, such as polysaccharides, get damaged but at pH 6-7, all conditions remain well.

4. Prevalence of plant diseases: Soil pH regulates the prevalence of plant diseases. Diseases are of two types, transmittable which is caused by pathogens, and non-transmittable which is caused by nutrient deficiency. Both are influenced indirectly by soil pH. For example, Streptomyces scabies, a soil-born pathogen responsible for sweet potato pox is favored at a pH of 5.2. But, when pH goes down to below 4.2, this pathogen cannot survive.

5. Bio-degradation: Soil pH was the most significant soil property in the degradation of atrazine. Generally, alkaline or slightly acidic pH promotes bio-degradation, on the other hand, acidic environments pose limitations to bio-degradation. Moreover, soil pH controls the soil structure. At high pH, soil structure gets broken down, pore space becomes clogged and water percolation is hampered.

6. Ammonia Volatilization: Ammonia volatilization is strongly correlated with pH and calcium carbonate, which suggested that the soil pH was a key factor in ammonia volatilization because calcium carbonate enhances soil pH which in turn regulates the concentration of ammonia and ammonium in soil solution

What causes the change in soil pH?

Natural soil pH depends on the rock from which the soil was formed (parent material) and the weathering processes that acted on it, for example climate, vegetation, topography and time. These processes tend to cause a lowering of pH (increase in acidity) over time. Some agricultural activities can also accelerate the acidification process.

Acidity or Basicity of fertilizers: The nitrate formed from nitrification of ammoniacal fertilizers that are not assimilated by plants leaches from the soil, leaving behind the acidity created in the nitrification reaction. Phosphoric acid released by dissolving phosphate fertilizer granules can lead to pH grades as low as 1.5 near the granule.

Organic matter influences pH: Soils with plenty of clay and organic matter content are more efficient to resist a drop or rise in pH (have a greater buffering capacity) than sandy soil. Clay material cannot be modified. We can modify organic matter content by management. Sandy soils generally are more close to acidic because of low organic matter content, resulting in a low buffering capacity, high rates of water percolation, and infiltration. Organic carbon cycling influences soil pH by producing CO2 releasing base cations upon degradation and forming aqueous organic acids. Research on the effects of organic matter input (e.g., crop residue, plant litter) or export (e.g., harvest) and soil pH has shown that pH changes are variable, and depend on soil properties (mineralogy, temperature, porosity, initial pH, etc.), plant species and management practices (e.g., notill, or burning). Crop residue input generally increases soil pH, and harvest decreases soil pH. Dissolved organic acids produced by microbes and plants are typically weak acids that create soil-solution acidity. However, they can also complex Al , removing it from solution, decreasing acidity.

Climate: Temperature and rainfall regulate leaching intensity and soil mineral weathering. In warm and humid environments, soil pH drops over time in a process called soil acidification. Rainwater has a slightly acidic pH (usually about 5.7) due to a reaction with CO2 in the atmosphere that produces carbonic acid. When this water flows through the soil it results in the leaching of basic cations from the soil as bicarbonate; this increases the percentage of AI and H relative to other cations. In dry climates, soil weathering and leaching are less severe. That's why pH can be neutral or alkaline.

Soil management: Soil pH is influenced by land use and management. Vegetation type impacts soil pH. For example, regions of forestland tend to be more acidic than regions of grassland. Conversion of land from forestland or grassland to cropland can result in severe pH changes after a few years. Because of the loss of organic matter and removal of soil minerals when crops are harvested, these changes in pH have occurred. These changes also happen for the effects of nitrogen and sulfur fertilizers.

Plant root: When roots take up cation and anion nutrients, they maintain electrical neutrality in plant root cells by absorbing or releasing H ions, organic acids, and OH ions. When plants take up more cations than anions, acidification is seen. This causes rhizospheres to be more acidic than the surrounding soils. Production of organic acids by plant roots and microbes, and respiration that enhances the partial pressure of CO2 in the rhizosphere also cause rhizosphere acidification.

Pollution: Mine wastes containing iron pyrite (FeS) and other sulfides added to soils can result in highly acidic soil conditions. Drainage of estuaries or wetlands containing high-sulfide sediments (acid-sulfate soils) also generates low pH soils. Acid rain caused by industrial releases of SO and NOx gases is a widespread problem for the natural landscape. The gases emitted from coal combustion, for example, create nitric and sulfuric acid vapors which are mixed with rain and acidify soils.