



Understanding Soil Acidity: Causes, Impacts, and Solutions

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Acidic soil refers to soil that has a pH level below 7, indicating an excess of hydrogen ions (H⁺) in the soil solution. It is characterized by a higher acidity compared to neutral or alkaline soils. When the concentration of hydrogen ions increases, the soil becomes more acidic. This increase in acidity can have a profound impact on soil health, nutrient availability, and plant growth. Acidic soil can occur naturally or result from human activities. Acid soils occupy 3950 million hectares (Mha) of ice free land of the world. It come into Spodosols, Alfisols, Inceptisols, Histosols, Ultisols and Oxisols soil orders with udic or ustic moisture regimes (von Uexkull and Mutert, 1995). In India, about 48 m ha out of 142 m ha of arable land are affected by acidity, of which 25 m ha have pH below 5.5 and 23 m ha have pH between 5.6 and 6.5 (Mandal 1997). Understanding the causes, impacts, and solutions related to soil acidity is most importance for farmers, agronomists, environmental scientists, and policymakers alike.

Source of soil acidity

Soil acidity can arise from various sources, both natural and human-induced. Here are some common sources of soil acidity:

- 1. Weathering of Minerals:** Natural processes of rock weathering contribute to soil acidity. Certain minerals, such as sulfides, release sulfuric acid when exposed to air and water, thereby increasing soil acidity. Aluminium and iron polymer also responsible for soil acidity (Hue, 2022).
- 2. Organic Matter Decomposition:** As organic matter, such as plant residues and animal waste, decomposes in the soil, organic acids are produced. This decomposition process can contribute to soil acidity over time.
- 3. Acidic Rainfall:** Acid rain (pH 4), resulting from air pollution caused by industrial emissions and combustion of fossil fuels, contains sulfuric and nitric acids. When acidic rainwater infiltrates the soil, it can lower the pH and contribute to soil acidity.
- 4. Agricultural Practices:** Certain agricultural practices can lead to soil acidity. Overuse of nitrogen-based fertilizers, such as ammonium-based fertilizers, can increase soil acidity as the ammonium ions are converted to nitrate ions, releasing hydrogen ions in the process (FTRC, 2015).
- 5. Acidic Amendments:** Some amendments or inputs used in agriculture, such as sulfur-containing fertilizers or acidic irrigation water, can introduce acidity to the soil.
- 6. Improper Land Management:** Improper land management practices, including excessive tillage, inadequate soil erosion control, and poor organic matter management, can accelerate

soil acidification. These practices can deplete soil nutrients and organic matter, leading to increased acidity.

7. Industrial Pollution: Industrial activities, such as mining and manufacturing processes, can release acidic emissions into the environment. These pollutants can eventually find their way into the soil, contributing to soil acidity (Yadav, et al 2020).

It's important to note that the severity of soil acidity and its specific sources can vary depending on regional and local conditions

Impact of soil acidity

The impacts of soil acidity can have far-reaching consequences on plant growth, nutrient availability, soil health, and ecosystem functioning. Understanding these consequences is crucial for developing effective strategies to mitigate and manage soil acidity. Here are some key impacts of soil acidity:

1. Nutrient Availability: Soil acidity can significantly affect the availability of essential nutrients to plants. Acidic conditions can reduce the solubility and accessibility of nutrients like phosphorus, calcium, magnesium, and certain micronutrients. As a result, plants may experience nutrient deficiencies, leading to stunted growth, reduced yields, and lower quality produce.

2. Soil Microbial Activity: Soil acidity can influence the activity and diversity of soil microorganisms, including bacteria, fungi, and other beneficial soil organisms. Many soil microorganisms have optimal pH ranges for their growth and functioning. Acidic conditions can disrupt the microbial balance and decrease the activity of beneficial microbes, which play crucial roles in nutrient cycling, organic matter decomposition, and disease suppression.

3. Toxicity and Element Imbalances: Soil acidity can lead to the release of certain toxic elements, such as aluminum and manganese, into the soil solution. These elements can become more soluble and bioavailable under acidic conditions, posing toxicity risks to plants. Additionally, high acidity can disrupt the balance of essential nutrient elements, such as calcium, potassium, and magnesium, further impacting plant health and growth.

4. Plant Health and Disease Susceptibility: Acidic soils can weaken plants and make them more susceptible to various diseases and pests. Reduced nutrient availability, impaired root growth, and weakened plant defense mechanisms in acidic conditions can increase plant vulnerability to pathogens and pests (Husson, et al 2021), impacting overall plant health and productivity.

5. Ecosystem Implications: Soil acidity can have cascading effects on ecosystems. It can alter plant communities, reduce biodiversity, and impact the functioning of terrestrial ecosystems. Acidic soils can also contribute to the acidification of nearby water bodies when acidic runoff or leachate enters streams, rivers, and lakes, leading to detrimental effects on aquatic ecosystems.

Management of soil acidity

Managing soil acidity is crucial for restoring soil health, optimizing nutrient availability, and promoting productive agricultural systems. Several strategies can be employed to effectively manage and restore acidic soils. Here are some key approaches:

1. Liming: Lime application is a commonly used method to raise soil pH and reduce acidity. Agricultural lime, typically in the form of ground limestone or dolomite, is added to the soil to neutralize acidity (Athanas, et al 2013). The amount of lime required depends on the soil's buffering capacity and target pH. It's important to consider factors such as lime quality, application method, and timing to maximize effectiveness.

2. Soil Amendments: Organic amendments, such as compost, manure, and green manure cover crops, can help improve soil structure, increase organic matter content, and enhance

nutrient cycling. These amendments can gradually reduce soil acidity over time and provide a favorable environment for microbial activity and nutrient availability.

3. Nutrient Management: Proper nutrient management is essential for addressing soil acidity. Balanced fertilization, based on soil nutrient analysis, helps maintain optimal nutrient levels and minimize nutrient imbalances that can exacerbate acidity (Fageria et al 2011). It is important to apply fertilizers that are suitable for specific soil types and crops, considering their potential acidifying or alkalizing effects.

4. Crop Rotation and Diversification: Implementing crop rotation and diversification practices can benefit soil acidity management. Some crops are more tolerant to acidic soils, while others may exacerbate acidity. By rotating crops with different pH preferences, the cumulative effects of acidity can be mitigated. Additionally, incorporating leguminous cover crops can enhance soil fertility and nitrogen fixation, reducing the need for acidifying nitrogen-based fertilizers.

5. Irrigation Management: Irrigation water can have varying pH levels, and its composition can influence soil acidity. Monitoring and managing the pH of irrigation water can help prevent further acidification of the soil. Acidic irrigation water may need treatment to adjust its pH before application to prevent additional soil acidification.

6. Conservation Tillage: Reducing or minimizing tillage practices can help manage soil acidity. Excessive tillage can accelerate the breakdown of organic matter and release of carbon dioxide, leading to increased soil acidity. Adopting conservation tillage techniques, such as no-till or reduced tillage, helps maintain soil structure, organic matter content, and pH stability.

7. Sustainable Land Management Practices: Implementing sustainable land management practices, such as erosion control, proper drainage, and the prevention of soil erosion, helps maintain soil structure and prevent the loss of essential nutrients. These practices contribute to overall soil health and minimize the risk of soil acidification.

Conclusion

Understanding soil acidity is essential for maintaining soil health, optimizing agricultural productivity, and promoting sustainable land management practices. Soil acidity can arise from natural processes such as weathering and organic matter decomposition, as well as human activities including fertilizer use and industrial pollution. The impacts of soil acidity range from reduced nutrient availability and impaired plant growth to changes in soil structure and ecosystem functioning. However, through effective management strategies, such as lime application, soil amendments, nutrient management, and sustainable practices like crop rotation and conservation tillage, soil acidity can be mitigated and soil health can be restored. By implementing these solutions, we can enhance nutrient availability, promote beneficial microbial activity, improve plant health, and safeguard the long-term sustainability of our soils and ecosystems.

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