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Why Soils Turn Sour: Formation and Chemistry of Acidic Soils

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Introduction

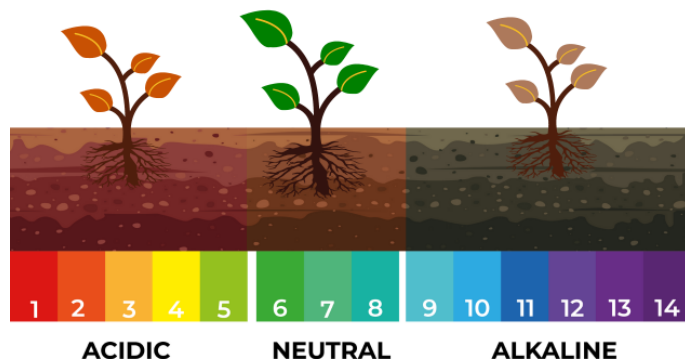
Have you ever seen a field where the crops look weak and stunted, even though the farmer applied fertiliser on time? Or have you ever wondered why tea gardens do so well on misty hills while crops like wheat and pulses have a hard time growing in the same kind of soil? The answer is often not in the seeds or fertilisers, but in the soil's secret chemistry.

Soils are often seen as simple ground beneath our feet, yet they are among the most complex living systems on Earth. Within a handful of soil exists a universe of minerals, microorganisms, water, and chemical reactions working together to support plant life. When soils become too acidic, farmers describe them as “sour.” Across the world, millions of hectares of farmland are slowly becoming “sour.” This doesn't mean the soil has a taste; it means its chemistry has changed. When soil turns acidic, nutrients become locked away, roots struggle to grow, and crops begin to lose their strength. The transformation is gradual almost silent but its impact on agriculture can be enormous.

Understanding why soils turn sour is not just a matter of science written in textbooks; it is a story that unfolds quietly beneath every field and farm. As we uncover the hidden processes that slowly turn fertile land acidic, we begin to see how closely soil health is tied to the future of agriculture itself. Learning this story allows us to manage soils with greater care, revive their lost productivity, and protect the living foundation that feeds the world.

Did You Know?

- **Nearly one-third of India's cultivated lands are acidic** about **49 million hectares** have a soil pH below 6.5. Of this, around **26 Mha is strongly acidic (pH < 5.6)** and **23 Mha is moderately acidic.**



- In India’s Northeast region, over 80 % of soils are acidic, and nearly 65 % of these soils have strong acidity (pH < 5.5).
- Some states in India have more acidic soils than the national average. In Manipur, around 72 % of land is acidic; Nagaland over 90 %; and Tripura about 68 %.
- Acid soils are rare or absent in the arid north-west states like Punjab, Haryana, Rajasthan, and Gujarat do not naturally have significant acidic soil areas.

What does “Sour Soil” mean?

Imagine tasting a slightly sour fruit; not spoiled, but clearly different from something sweet. Farmers use a similar idea when they describe certain fields as “sour soils.” Of course, no one actually tastes soil. The term simply refers to soils that have become acidic, meaning their chemical balance has shifted in a way that affects plant growth.

Scientists measure soil acidity using something called the pH scale. This scale ranges from 0 to 14. A pH of 7 is neutral, values below 7 are acidic, and values above 7 are alkaline. Most crops grow best when soil pH stays between about 6.0 and 7.0, a range where nutrients

are easily available and roots can grow comfortably. When the pH drops below 6.5, soil begins to turn acidic, and when it falls below 5.5, it becomes strongly acidic and more challenging for many crops.

Why Do Soils Turn Sour?

Soil does not become acidic overnight. The process is slow, natural, and sometimes accelerated by human activity. Let us uncover the hidden reasons behind soil acidity.

1. Heavy Rainfall and Leaching

In high rainfall regions, water moves downward through the soil profile. As it flows, it washes away basic nutrients such as calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na). These nutrients act like natural “buffers” that keep soil neutral.

When they are leached away, hydrogen ions (H^+) and aluminum ions (Al^{3+}) dominate the soil. Over time, this increases soil acidity.

This is why regions with high rainfall such as hill areas and tropical zones often have acidic soils. For example, many soils in the tea-growing hills of India are naturally acidic, which suits tea but not crops like wheat or pulses.

2. Nature of Parent Material

Soil is formed from rocks. If the parent rock material is already low in basic minerals and rich in acidic components, the soil formed from it will naturally tend toward acidity. Granite and sandstone-based soils are often more acidic compared to soils formed from limestone.

3. Use of Acid-Forming Fertilizers

Modern agriculture heavily depends on nitrogen fertilizers such as urea and ammonium sulfate. While these fertilizers boost crop growth, their continuous use gradually increases soil acidity.

When ammonium (NH_4^+) fertilizers are converted into nitrate (NO_3^-) through nitrification, hydrogen ions are released into the soil. Over time, this lowers soil pH.

This means that even fertile soils can slowly turn sour if fertilizer management is not balanced.

4. Crop Harvesting and Nutrient Removal

Every time crops are harvested, nutrients are removed from the field. If these nutrients especially calcium and magnesium are not replenished, the soil gradually loses its buffering capacity and becomes acidic

5. Decomposition of Organic Matter

When plant residues and organic matter decompose, they produce organic acids. In moderate amounts, this is beneficial. However, continuous accumulation without proper management can contribute to acidity.

6. Industrial Pollution and Acid Rain

In some regions, industrial emissions release sulfur dioxide (SO₂) and nitrogen oxides (NO_x) into the atmosphere. These gases combine with rainwater to form weak acids, leading to acid rain. Repeated exposure gradually lowers soil pH.

Table.01. Indian State-Wise Acid Soil Overview

Region / State	Approx. Acidic Soil Coverage
North-East Region (total)	~37 % of land area is acidic
Manipur	~72 % acidic soils
Nagaland	~91 % acidic soils
Tripura	~68 % acidic soils
Meghalaya	~46 % acidic soils
Assam	~25 % acidic soils
Sikkim	~8 % acidic soils
Other Parts of India	~49 Mha acidic soils total (~30 % of cultivated land)
Kerala	Large acidic soil presence due to lateritic formations and rainfall (majority of state)
Odisha, Jharkhand, West Bengal, Chhattisgarh	Significant acidic land pockets in rainfed and upland areas
Andhra Pradesh, Karnataka, Tamil Nadu	Moderate acidic soils found especially in upland and lateritic zones
Punjab, Haryana, Rajasthan, Gujarat	Minimal or no natural acidic soils reported

What Happens When Soils Turn Sour?

Soil acidity affects crops in several hidden but powerful ways.

1. Nutrient Locking

- In acidic soils, Phosphorus becomes fixed and unavailable, Calcium and magnesium levels decline, Molybdenum deficiency may appear.
- Even if fertilizers are applied, crops may not benefit because nutrients become chemically “locked.”

2. Aluminum Toxicity

- When soil pH falls below 5.5, aluminum becomes soluble. This is dangerous for plant roots.
- Soluble aluminum, Damages root tips, restricts root growth, Reduces water and nutrient uptake.
- Plants appear stunted, with poor vigor and yellowing leaves.

3. Poor Microbial Activity

Beneficial soil microorganisms prefer near-neutral pH. Acidic conditions reduce microbial activity, slowing decomposition and nutrient cycling.

This weakens the soil's natural fertility system.

4. Reduced Crop Yield

Sensitive crops such as wheat, maize, pulses, and many vegetables struggle in acidic soils. Yield losses can be significant if acidity is not corrected.

Interestingly, some crops like tea, pineapple, and potato tolerate acidity better which is why tea thrives in acidic hill soils.

What Can Be Done?

The good news is that sour soils can be corrected and revived.

1. Liming - The Most Effective Solution

Applying lime (calcium carbonate) is the most common practice to correct soil acidity.

Lime:

- Neutralizes excess hydrogen ions
- Reduces aluminum toxicity
- Restores nutrient availability

The amount of lime required depends on soil pH and soil type. Soil testing is essential before application.

2. Use of Organic Matter

Adding compost, farmyard manure (FYM), or green manure, improves soil buffering capacity, enhances microbial activity, Improves soil structure.

Organic matter does not replace lime but supports long-term soil health.

3. Balanced Fertilizer Use

Avoid excessive ammonium-based fertilizers, Use integrated nutrient management, Combine chemical fertilizers with organic inputs. This prevents rapid acidification.

4. Growing Acid-Tolerant Crops

In strongly acidic soils, farmers may grow crops adapted to such conditions, such as

Tea, Pineapple, Tapioca, Certain millets. This is a practical short-term strategy.

The Bigger Picture: Why Soil Acidity Matters for the Future

Soil acidity is not just a field-level issue; it is a food security concern.

Globally, nearly 30–40% of arable land is estimated to be affected by acidity to some degree. In tropical and subtropical regions where rainfall is high and nutrient leaching is intense acidic soils are especially widespread. In India, large areas of the North-East, eastern states, parts of Odisha, Jharkhand, Chhattisgarh, West Bengal, Kerala, and the Western Ghats are dominated by acidic soils. These regions are also home to millions of small and marginal farmers whose livelihoods depend directly on soil productivity.

Unchecked soil acidity can reduce fertilizer efficiency by 20–50%. That means farmers may spend more on inputs but harvest less in return. It also increases vulnerability to drought, because shallow and damaged root systems cannot access deeper soil moisture. In a changing climate, where rainfall patterns are becoming unpredictable, maintaining healthy root growth becomes even more critical.

There is also a sustainability angle. When soils become too acidic, farmers often compensate by applying more fertilizers. Without proper management, this can lead to nutrient imbalances, runoff losses, and environmental stress. Correcting acidity, therefore, is not only about improving yields it is about improving efficiency and reducing unnecessary input costs.

Healthy soil pH is the foundation of nutrient balance, microbial activity, and root development. When that foundation shifts, the entire system feels the impact.

So, the next time crops look weak despite proper fertilization, the answer may not lie in adding more inputs but in understanding the quiet chemistry beneath our feet.

Because soil does not simply support agriculture. It determines its future.

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